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# The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

## EDITORIAL

### THE SURGERY OF THE LARGE BOWEL

IN 1879 Schede resected a tumor of the colon and, being unable to make an anastomosis, performed a double barrelled colostomy. In 1885 Kraske presented his sacral operation for malignancy of the rectum before the fourteenth Congress of German Surgeons, and in 1892 Block of Copenhagen was the first to perform exteriorization of the colon without resection of the growth. In the same year Paul of Liverpool extended the principle of exteriorization with resection, a procedure later to be popularized and associated with the name of Mikulicz (1902). These contributions stimulated the study and progressive development of the principles of colonic surgery.

Malignancy of the large intestine occurs about as frequently as malignancy of the stomach and fully 75 per cent of all organic diseases of the colon are malignant. In spite of the frequency of malignancy of the large bowel and contrary to the general hopefulness of surgical intervention, we are aware of a general professional apathy; a sense of defeatism in the minds of general practitioners and among many of the internists. The general practitioner will ordinarily be the first doctor to make a diagnosis or at least be suspicious of the presence of a bowel malignancy. The diagnosis of neoplasm of the large intestine can be made with great precision and relatively inexpensively. The procedures for an ac-

curate diagnosis are not many or detailed, nor do they involve extensive laboratory studies. All that is required is a searching inquiry into the bowel habits of the individual, a complete physical examination including proctoscopy or sigmoidoscopy, and the utilization of the roentgenologist. In few fields of surgical diagnosis are the means for diagnosis so readily available and so easily applied and carried out.

The establishment of colon clinics in our general hospitals, the increase in post-graduate instruction, and the education of the laity have developed to a slight degree a so-called "colon-consciousness," and yet fully two-thirds of the patients who come to surgery have had their neoplasm for a considerable period of time. Rankin states the significant statistical fact that about as many patients with carcinoma of the right half of the colon are operated upon for chronic appendicitis and chronic cholecystitis as patients with carcinoma of the rectum are operated upon for hemorrhoids. On the other hand, the surgical observer is rather surprised with the rarity of exploratory laparotomy for disease of the colon.

The advances that are to be made in the cure of patients with malignancy of the large bowel will depend upon an increase in the percentage of operability. When only 20 per cent of the individuals seeking surgical relief for malignancy of the colon are considered reasonably operable cases

there are obvious deficiencies in early diagnosis in that community. When one contrasts this with an operability of 50, 60 or even 65 per cent in some of the best equipped colon clinics we may be sure that after the five year interval there may be an increase in hospital mortality but there will be considerably more persons alive and well than when the low percentage of operability obtains.

Of great importance in the consideration of malignancies of the rectum is that the psychology of a patient with this disease is markedly different from that of the individual with a carcinoma of the stomach. The man who has had a radical resection for carcinoma of the stomach is not at all times reminded of his malady and if recurrence occurs he has no disturbing discharge of stool from a colostomy. Contrast the terror that is present in the mind of an individual who has survived radical abdominoperineal resection of the rectum and has a permanent colostomy. How often do we hear the expression "I would rather be dead than have a permanent colostomy" and yet a permanent colostomy is not incompatible with a life of activity and well being. The mental distress of losing the normal mechanism for bowel evacuation is in many patients at present insurmountable, and until the profession generally changes their viewpoint—erroneous to be sure—in regard to permanent colostomies, the physician cannot expect to carry to the patient a high degree of optimism.

It is the hope of the Guest Editor that the field of surgery of the large bowel and rectum has been adequately covered in this Symposium. There will be overlapping by the various authors and this has been desired. Opinions will perhaps differ in regard to some of the technical details yet the philosophy underlying this subject and

its rationalization will be apparent as a continuous story that runs through all of the contributions.

The various authors are unusually qualified in experience and technical ability. The subject of malignancy of the large bowel occupies first place in the symposium. Neoplasms are considered generally and regionally. Consideration is given to the many and diverse factors that attend localization and metastases. Variations in the application of technical procedures to the disease and the patient are discussed and the reasons given for the modification of classical operations by reason of the localization of the tumor. Decompression operations are an integral part of the technical subject and ordinarily are not included in our textbooks. The problem of one-stage or two-stage operations, the anterior and posterior approaches, the mortality and morbidity factors, the various postoperative complications, together with recent additions to our knowledge of chemical and water balance, occupy a prominent place in this Symposium.

Discussions of the incidence and treatment of diverticulitis, polyposis, gunshot wounds and colon trauma, cicatrizing obstructing inflammation of the bowel, chronic ulcerative colitis, and instrumental diagnostic aids plus roentgenology make for completeness.

It would appear that surgery of the large bowel is beginning to occupy its true place in modern surgery and it is our earnest hope that the sense of terror that has heretofore prevailed in the minds of some practitioners, no less than in those of the patients, is in the course of being dispelled.

The Guest Editor desires to express his personal appreciation and thanks to all the contributors to this Symposium.

CHARLES GORDON HEYD, M.D., F.A.C.S.



# ORIGINAL ARTICLES

## NEOPLASMS OF THE CECUM AND ASCENDING COLON\*

FRANK H. LAHEY, M.D.

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ONE of the reasons that the end results of radical removal of segments of the colon for carcinoma of that structure are so good (42 per cent of the patients are alive and well without recurrence over five years, in our hands) is due to the fact that 75 per cent of the malignancies of the large bowel occurred in the descending colon, sigmoid, recto-sigmoid and rectum. The good results are related considerably to the fact that lesions as close to the anus as those located in these segments are, tend to produce early attention—attracting symptoms so that diagnoses are made in time to obtain good end results.

In carcinomas of the sigmoid and rectum occurring in our experience (we have now operated upon over a thousand patients with carcinoma of the colon and rectum) in 80 per cent of the cases with lesions located at these levels the lesion was palpable either through the abdomen or by rectum. When also one realizes that the feces at this level are solid and thus tend to produce early obstructive lesions and, in ulcerating lesions, bleeding, it is likewise obvious why these lesions give early evidence of their presence.

Dr. Swinton, who is in charge of the proctological department in the Lahey Clinic, has analyzed the histories in 100 proved cancers of the right colon, 100 proved cancers of the left colon and 100 proved cancers of the rectum and found that of the entire group, there was an alteration in bowel function or abdominal cramps or pain or abnormal stools

in 97.7 per cent of the cases. When we analyze these figures, as shown in Table I, however, it is to be noted that in the rectum 86 per cent had abnormal stools, in the left colon 46 per cent had abnormal stools, but in the right colon but 9 per cent had abnormal stools.

TABLE I  
SYMPTOMS OF CARCINOMA OF THE COLON AND RECTUM  
(300 CASES)

	Rectum, Per Cent	Left Colon, Per Cent	Right Colon, Per Cent	Total, Per Cent
Blood in stool.....	86	46	9	46
Altered bowel function.....	79	82	81	80
Abdominal cramps or pain.....	7	77	86	47
None.....	2	2	3	2.3

In lesions of the right colon, therefore, the feature in the history of abnormality in the stools which is so often present in malignant lesions of the left colon and rectum, is lost.

We have often stated that the physiologic function of the right colon plays a considerable part in the symptomatology of lesions in the cecum and ascending colon and likewise has much to do with the mortality of operative procedures in this region.

Due to the fact that the contents of the right colon are liquid in character, due to the fact that the liquid contents of the right colon are rich in highly virulent

\* From the Department of Surgery, the Lahey Clinic, Boston, Massachusetts.



organisms, operative procedures such as direct anastomosis when associated with any contamination are particularly apt to result in peritonitis.

Likewise, due to the fact that the contents of the right colon are liquid in character, rarely does one see obstructive symptoms in malignancies at this level until the lesions are so well advanced that they completely or almost completely encircle the caliber of the colon and are thus often in late and inoperable stages. The only exception to the appearance of obstructive symptoms early in lesions of the right colon is when the malignancy of the cecum is close to the ileocecal valve and involves that structure. Relatively early, and relatively small lesions in this location can produce obstructive symptoms even up to complete obstruction.

The outstanding clinical feature by which early diagnosis may often be made in lesions of the cecum and ascending colon is secondary anemia. Why secondary anemias should be so consistently associated with malignancies of the cecum and ascending colon has never been adequately explained. It has been suggested by many that absorption of the noxious toxins from the highly virulent organisms in the warm moist culture media of the liquid feces of the right colon through the ulcerating base of the malignant lesion may well explain this secondary grade of anemia. While this is possible, it hardly seems an adequate explanation of the severe grades of anemia, giving the patient the typical lemon yellow color of intense secondary anemias that occur with these diseases. It has often been possible for me to make the diagnosis of probable carcinoma of the right colon merely from the color of the patient and from his statement before examination that he has vague pains in the right side of the abdomen. I know of no malignant lesion where such severe blood changes can appear and produce such changes in the facial appearance of the patient as with secondary anemia associated with lesions of the ascending colon. Certainly it is true

that there appears to be no parallel situation in malignancy where such severe grades of secondary anemia can be present with the lesion still readily operable and the patient within a stage where radical removal can result in non-recurrence. Should such severe grades of secondary anemia be found associated with malignant lesions elsewhere, they would in practically all instances indicate metastases and non-operability of the lesion. One should bear in mind in dealing with lesions of the proximal colon that this exception as relates to the anemia exists.

It is unfortunate that one does not see in lesions of the cecum and ascending colon bright blood in the stools. Should bleeding occur it becomes so intimately mixed with the liquid fecal contents of the colon at this level that it is recognized only by studies for occult blood. Studies for occult blood, however, will rarely fail to show positive findings in the presence of malignant lesions of the right colon. In patients suspected of having malignant lesions of the colon anywhere it will always be wise to make careful studies for occult blood because rarely will malignant lesions of the colon at any level exist in the absence of occult blood in the stools.

X-ray findings in malignant lesions of the cecum and ascending colon are particularly apt to be confusing. Due to the fact that the cecum and ascending colon often have long mesenteries and are often redundant, when these structures are filled with barium the defects in the outline of early malignant lesions can be so located on the posterior wall that they are overshadowed by the distended overlying redundant cecum and ascending colon and easily overlooked.

It will frequently be necessary, from our experience, to repeat barium enemas in patients suspected of having lesions of the cecum and ascending colon and in addition to that, it will be necessary at times to send these patients home for a period of four to five weeks and to have them return for repeat enemas to check with the

original film. Exclusive of malignant lesions at the level of the rectosigmoid I know of no place in the whole colon where it is easier, particularly in early lesions, to overlook malignancies. It is unfortunate also that palpation of lesions in the right colon is frequently not positive until they are of considerable size and fairly advanced in character. It is easier as a rule to palpate lesions in the cecum and ascending colon than in the hepatic flexure where they are so often located deep under the outflaring arches of the ribs at this level.

One should have in mind always in the presence of an unexplained secondary anemia, particularly in any patient within the cancer age, the possibility of a malignant lesion of the ascending colon with little or no symptomatology associated with it. More than once in my own experience, failure to pay sufficient attention to an unexplained secondary anemia in the presence of other lesions has caused me to fail to diagnose a lesion of the cecum or ascending colon preoperatively only to find it to my chagrin and surprise during an operative procedure for another condition.

Frequently the only symptoms in patients with malignancies in the cecum and ascending colon are quite vague pain and feelings of bowel discomfort in the right quadrant. It has already been stated that when obstructive symptoms are present in lesions of the cecum and ascending colon one may be quite certain that the lesion is late. There is a quite dependable maxim associated with lesions of the large intestinal tract anywhere. There seems little question that the majority of the malignancies of the large intestine in the rectum, sigmoid, left colon and right colon originate in lesions which are primarily benign in character, that is, polyps and adenomas. Most surgeons who have had much experience and who are seriously interested in these disturbances are convinced of the association between polyps and carcinomas of the large intestine. It is for this reason that one may roughly assume that when a carcinoma of the large bowel at operation

or x-ray examination has been found completely encircling the lumen of the bowel, its age is usually between six months and a year. This is due to the fact that a lateral wall lesion requires from six months to a year to encircle the bowel wall completely.

Since the treatment of malignant lesions of the cecum and ascending colon is universally accepted as surgical the only discussion necessary is regarding the type of surgery to be applied.

One may remove the right colon by a variety of procedures. Preliminary anastomoses between the transverse colon and the ileum may be established and at the end of two weeks the entire right colon may be removed.

The entire right colon may be removed at one stage and at this same operation the ileum implanted into the transverse colon.

The entire right colon with several inches of the terminal ileum and the hepatic flexure may be removed in one block together with its mesentery, the ileum may be approximated to the transverse colon, tacked to the transverse colon by the Mikulicz plan and the ends implanted in the wound. This is the procedure which we have now employed for several years and the one which we think offers the greatest degree of safety to the patient, particularly as relates to the danger of peritonitis.

We by no means wish to state that either of the two other mentioned procedures may not be employed. I can only state the reason why I devised this modification of the Mikulicz plan to apply to malignant lesions of the right colon and our experiences with it.

We feel very strongly that because we have so many right colons to resect we do not wish to worry about the danger of leakage and peritoneal contamination with any type of primary intestinal anastomosis. While we have had a large experience with intestinal suture we do not have confidence in our ability to make intestinal anastomoses with such certainty that they can be dropped back into the abdomen with

the same lack of worry on our part as to the danger of leakage and peritonitis as in the modified Mikulicz procedure here

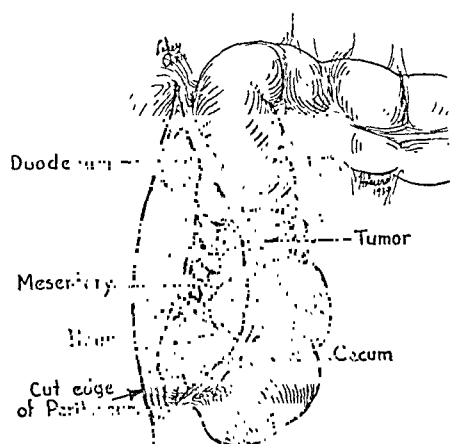


FIG. 1.

described. We do not mean to say that perhaps others cannot do primary anastomoses and intestinal sutures which leave them comfortable and unworried post-operatively. After having employed this modified Mikulicz type of procedure published by the author in 1932<sup>1</sup> we would not consider the employment of primary intestinal anastomoses if for no other reason than the confidence and peace of mind associated with the lack of danger of leakage and peritonitis with the modified Mikulicz plan of excision. We feel strongly that the large intestine with its often scanty blood supply, with its sacculated walls, its longitudinal bands and its epiploic appendages, with its highly virulent fecal content, lends itself most unfavorably to safe and dependable intestinal suture. We have therefore without reservation for several years assumed the position that when we resect the right colon it will be for practical purposes always by the modified Mikulicz plan here described.

This will necessitate approximately two months of discomfort on the patient's part while the fecal stream is at least in part discharged through the temporary colostomy

opening. We feel that this, however, is but little handicap to the patient during this time and one well worth accepting when by it the danger of possible leakage and peritoneal contamination can be largely eliminated.

What type of operation one employs is governed frequently by a variety of factors, such as: how bad risks does one accept; how confident does one feel of his ability to do safe intestinal anastomoses; and how much colon surgery has one done. These factors lead different individuals to employ different methods. It is impossible for any single individual to insist that the procedure which he employs is the one for everyone. We therefore describe here the method which we have consistently adhered to, not because we think that other methods cannot be employed, but because our own experience proves to us that other methods cannot be employed by us as satisfactorily or as safely as can this procedure.

Resection of the right colon is first undertaken by making a long, right rectus incision extending from the tip of the cecum to above the level of the hepatic flexure. The lesion is visualized, the right colon is picked up by the assistant with two pieces of gauze and pulled toward the midline, the wound edge being retracted outward in the opposite direction by the other assistant. The external parietal peritoneum attached to the outer border of the ascending colon is then incised as was advised by William J. Mayo, carrying this incision well around the hepatic flexure to the transverse colon. (Fig. 1.) This procedure completely mobilizes the colon and it may be so wiped inward that it is now hanging by its mesentery. As it is wiped inward the first structures coming into view in the male patient are the spermatic vessels and in the female, the ovarian vessels. Next, one comes to the retroperitoneal ureter which in the right lower quadrant is adherent to the peritoneum and must be wiped off from that structure. As one dissects the ascending colon toward the middle line at its upper point the retro-

<sup>1</sup>LAHEY, F. H. Resection of the right colon and anastomosis of the ileum to the transverse colon after the Mikulicz plan. *Surg., Gynec. & Obst.*, 54: 923-929 (June) 1932.

peritoneal duodenum comes into view and must be separated from the mesentery of the upper part of the ascending colon. (Fig. 2.)

Care must be taken in separating the retroperitoneal duodenum (1) lest the duodenum be injured and (2) lest undesirable rents in the mesentery be produced. When the entire mesentery is wiped toward the middle line, when the spermatic vessels have been wiped down together with the ureter and the retroperitoneal duodenum has been wiped off the root of the mesentery, the mesentery of the ileum is then exposed and ligated down to its root, carrying, as shown in Figure 3A, this ligation along the root of the mesentery of the ascending colon up to the point where the transection of the colon at the transverse colon is to take place.

Care should be taken to leave a small apron of mesentery at its root over the mesenteric vessels, the aorta and the vena cava to protect these structures. (Fig. 3A.)

which I employed in my original description of this plan. This will provide a spigot of devascularized ileum sticking out beyond

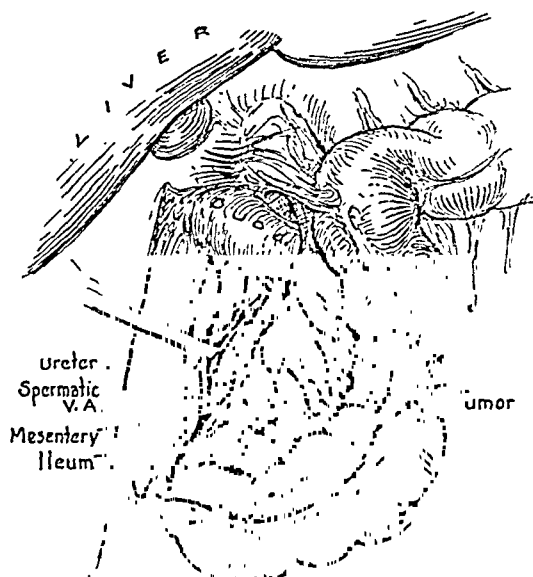


FIG. 2.

the abdominal wall, into which a glass tube may immediately be inserted after the operation. This secures immediate decom-

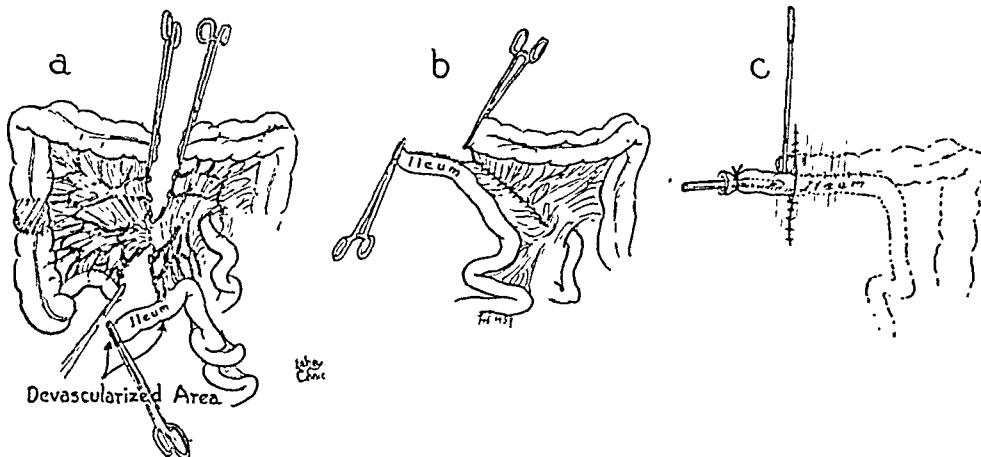


FIG. 3.

This small apron of peritoneum at the root of the mesentery likewise will provide a flap to suture to the apex of the triangle of mesentery removed with the ascending colon and hepatic flexure.

When the mesentery of the ileum is ligated, as shown in Figure 3A, about 4 inches of ileum is detached from its mesentery so that it is completely devascularized. This represents the portion of ileum which is to be staggered, the term

pression of the intestinal tract as soon as the operation is completed.

When the mesentery of the ileum and of the ascending colon and hepatic flexure has been completely ligated, two Ochsner clamps are placed on the ileum at the point where it is to be transected, and two more upon the transverse colon at the point where it is to be transected. The bowel between these two clamps is burned through with the actual cautery while the

surrounding structures are protected with drapes. The ends are thoroughly sterilized by means of the cautery. The segment of

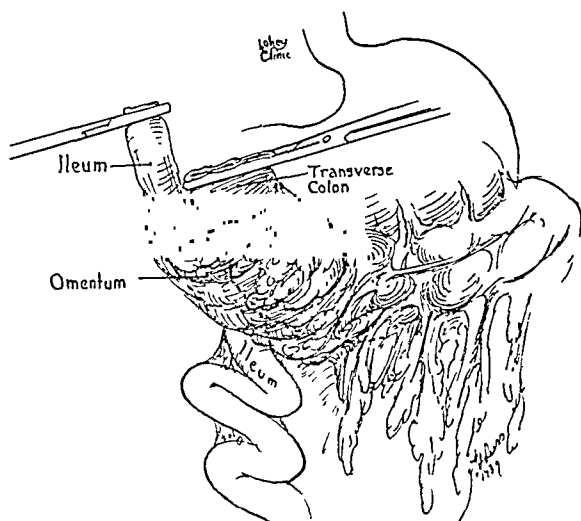


FIG. 4.

ascending colon and hepatic flexure containing the malignancy is now given to the pathologist and the preparation of the bowel for the modified Mikulicz procedure is undertaken. The ileum is placed beside the transverse colon, the rent in the mesentery made by the removal of the "V" of mesentery attached to the ascending colon and hepatic flexure is repaired (Fig. 3B), and a single row of tacking stitches of catgut is placed between the antemesenteric border of the ileum and the longitudinal band of the transverse colon. (Fig. 3C.) This double barreled Mikulicz approximation is tacked together for a distance of at least 6 or 7 inches.

One of the things that we have learned in doing so many modified Mikulicz procedures of all types is that one can make the Mikulicz spur too short, but one cannot make it too long. We have also learned that while one may adequately cut the Mikulicz spur down with clamps while the patient is in the hospital at the first stage, when he returns for the second stage, due to swelling and cicatrization, the septum may have so shortened up that it will require further cutting. It is for this reason that it is desirable to have a long approxima-

tion between the ileum and the transverse colon when the first operation is done.

With the ileum attached to the transverse colon, the remaining apron of omentum is now wrapped about the double barreled ileum and transverse colon, as shown in Figure 4, and the two loops of intestine implanted in the wound, the wound being closed snugly about the double barreled tube of intestine. No sutures are placed between the lumen of the bowel and the parietal peritoneum.

With the implantation of the double barreled loop within the sutured wound the first stage of the operation is completed and there remains only the necessity to drape the wound, to remove the clamp on the ileum which is serving as a spigot and to introduce a glass tube with a piece of rubber tubing connected to it which is carried to a bottle beside the bed, thus immediately accomplishing decompression of the intestinal tract. (Fig. 3C.)

At the end of four or five days the excess of nonvascularized staggered loop of ileum which has served as a spigot will slough off, so that the two ends of the Mikulicz, the colon and ileum, will then be at the same level within the wound. At this time an Ochsner clamp is introduced with one jaw in the colon and the other in the ileum and locked. (Fig. 5.) It is usually necessary to take approximately two bites with this clamp before a sufficient amount of the spur has been cut down. As soon as the spur has been severed some of the feces pass by rectum but a considerable amount still passes out through the colostomy made up of the now combined ileum and transverse colon.

These patients, as soon as the wound is healed, are sent home for a period of two months. We have tried reoperating upon these patients to close the temporary colostomy extraperitoneally earlier than this but this has proved undesirable. It requires two months for the peritoneum to become firmly attached to the Mikulicz intestinal loop and it requires two months for most of the edema to leave the wound

so that the bowel can be safely inverted in it.

At the end of two months the patients

We believe that the success of secondary closure of the colostomies associated with these Mikulicz procedures is related to

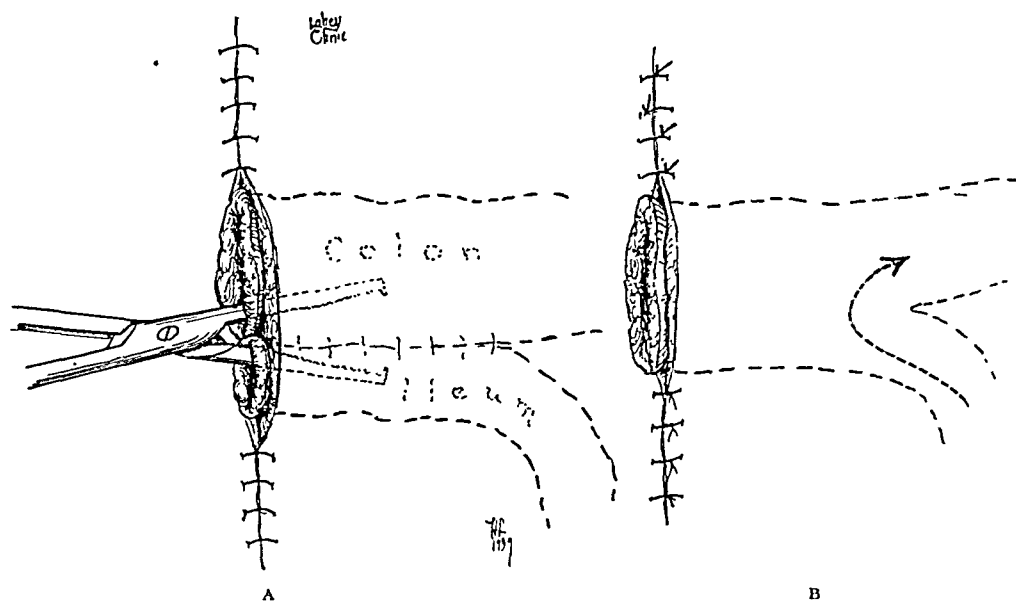


FIG. 5.

return in excellent condition, and under gas or spinal anesthesia an incision is made in the skin about the colostomy opening. (Fig. 6A.) This incision is carried down to the fascia. If the patient is thin the fascia and muscle are also separated from the wall of the bowel forming the colostomy. If the patient has a thick layer of fat we have found that it is not necessary to separate the tube of bowel from the fascia but this tube can be turned in and inverted down to the level of the fascia, and the fat closed over this. The end results prove to be quite as satisfactory as when the inverted end of bowel is buried beneath muscle and fascia.

We have now closed a great many of these secondary colostomies associated with these modified Mikulicz procedures and in none have we failed to accomplish complete closure.

Many visitors coming to the Clinic have complained that they have been able to close these temporary colostomies associated with the Mikulicz procedure with catgut but that at the end of ten days to two weeks fecal leakage occurred, with external drainage.

how thoroughly one denudes the wall of the temporary colostomy of its indurated fat and how thoroughly one severs any

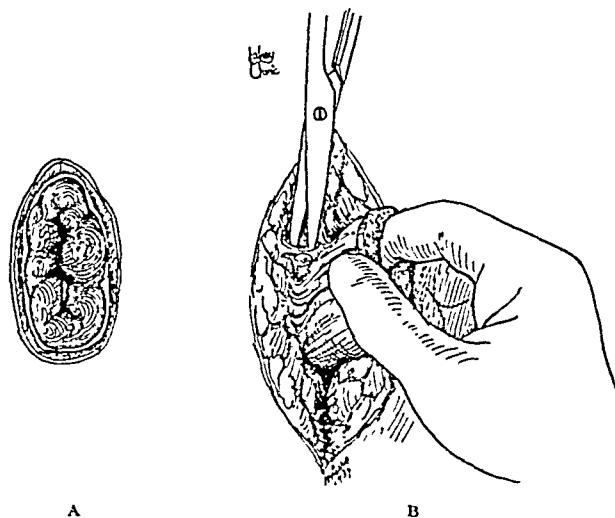


FIG. 6.

indurated mesenteric attachment to the colon. If one attempts to invert the tube of colon, as shown in Figure 7B, while indurated tabs of epiploic appendages or indurated segments of fat are attached to the wall, inversion can be accomplished with catgut, but only under tension; as soon as the catgut is absorbed eversion

and pouting of the intestinal mucosa will occur and result in an intestinal fistula. It is only when the intestinal tube has

being made to suture fascia over it. (Fig. 7B.) We have had no misfortunes with serious infections in these secondary closures.

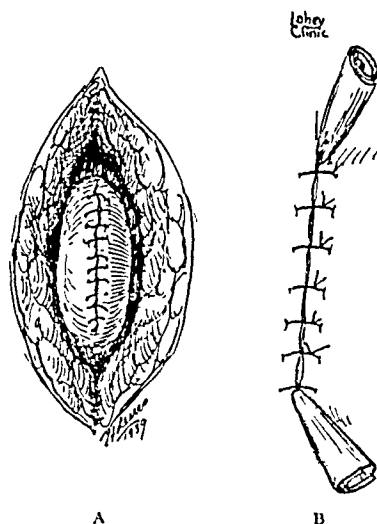


FIG. 7.

been so thoroughly freed of its indurated fat that it is as flexible as normal intraperitoneal bowel, that complete, satisfactory and accurate inversion suture can be accomplished.

It was not until we learned thoroughly to free the tube of bowel, to drape the wound with gauze about the bowel and to insert a finger within the fecal contaminated lumen of the bowel so that we could use this as a guide upon which to excise the indurated tabs of fat that we satisfactorily accomplished inversion with uniformity. This is the only method by which we feel that it is possible to free this tube of bowel of its fat so that it can be inverted with satisfaction and with security. (Fig. 6B.)

The in-out-and-over suture devised by Connell is employed to invert the flexible wall of bowel thoroughly. (Fig. 7A.) An additional row of mattress sutures is then employed to invert the bowel further. If the patient is thin, as already has been stated, fascia and also muscle are sutured over the inverted bowel. A small segment of rubber dam is placed at the upper and lower ends of the wound. If the patient is fat, the inverted bowel is placed only below the level of skin and fat, no attempt

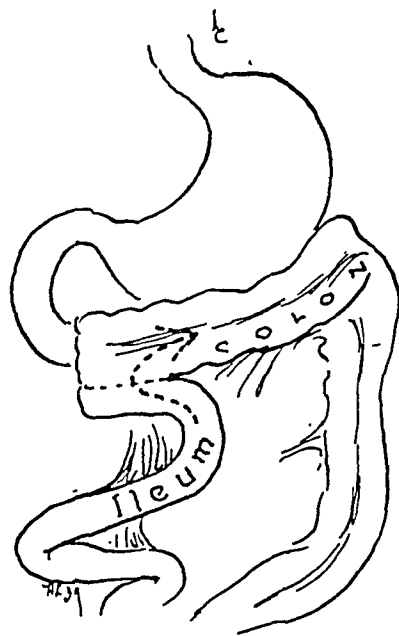


FIG. 8.

We believe as a result of a large experience with resections of all levels of the colon by the modified Mikulicz plan of procedure that one can safely say that this plan in no way limits the radicalness of the operation. At least in our hands it eliminates all fear and danger of peritoneal contamination and fatalities as the result. It permits complete and satisfactory restoration of the fecal stream without the production of obstruction or even constipation; Figure 8 shows the fecal stream after a Mikulicz resection. It has now been employed in this Clinic a sufficient number of times so that these points have been established to everyone's satisfaction.

#### CONCLUSIONS

The symptomatology of carcinoma of the cecum and ascending colon unfortunately is much more vague than in the left colon.

Fortunately but 16 per cent of the carcinomas of the colon occur in the cecum, ascending colon and hepatic flexure.

Unexplained secondary anemia should make one extremely suspicious of the presence of a possible carcinoma of the cecum or ascending colon.

X-ray diagnosis of carcinoma of the cecum and ascending colon is surrounded by pitfalls. Should there be any doubt, the x-ray examination should be repeated in

a period of four to five weeks and even once again at the end of a similar period.

The modified Mikulicz plan of procedure has been employed in this Clinic almost without exception for a number of years and has given gratifying satisfaction.

Illustrations and the technical description of this operative procedure are submitted.



It can be fairly stated that bleeding from the bowel is the most important single symptom pointing to organic disease of the intestinal tract. . . . It is an indication of a break in the mucosa of the bowel somewhere along its course, or in the epithelium of the anal canal.



# SURGICAL REMOVAL OF LESIONS OCCURRING IN THE SIGMOID AND RECTOSIGMOID

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THERE is little controversy concerning the resection of the upper segment of the sigmoid which is sufficiently mobile to permit of exteriorization. The field of controversy concerns that portion of the pelvic colon which extends from the *midsigmoid through the rectosigmoid*. If conditions permit the involved portion of the intestine to be exteriorized I prefer to carry out an obstructive type of resection over a three-bladed clamp in preference to utilizing the Mikulicz method. Should the lesion be situated in that portion of the pelvic colon which cannot be exteriorized, I elect, if possible, to carry out a type of operation which leaves the sphincteric mechanism intact but nevertheless removes the malignant lesion in a radical manner.

The Mikulicz type of exteriorization has been employed with satisfactory results in many instances, but it is important to keep in mind that the true Mikulicz operation is not sufficiently radical to remove involved mesenteric lymph nodes. In cases in which it is employed the affected segment is exteriorized and covered by vaseline gauze; removal of the segment is effected several days later. When study was made of a large series of cases observed at the Mayo Clinic it was found that recurrence of the malignant process had developed in the abdominal wall in about 15 per cent of the cases. It may be safely stated then that a more radical type of operation offers a better chance of permanent relief from the malignant disease.

When I remove a lesion situated in the first portion of the sigmoid I first freely mobilize the segment of bowel to be resected. Then a generous v-shaped portion of the adjacent mesentery is incised and the

vessels are ligated in anticipation of removal of that part of the intestine. The mobilized diseased segment of sigmoid and mesentery is covered with gauze and brought out through the incision. Next, the wound is closed in layers in the usual manner, which consists of suturing the layers of the abdominal wall in such a way that they finally approximate closely the normal portion of the two limbs of the exteriorized colon. The wound is covered by moist gauze packs. Clamps are applied to the limbs of the protruding segment of bowel which is then amputated by means of cautery. In eighteen to twenty-four hours the proximal limb of colon is punctured immediately beneath the clamp. The clamps become detached automatically in five or six days; following this, a spur-crushing forceps is applied. After two to four weeks have elapsed, the colonic stoma is closed. This procedure seems more radical than the Mikulicz operation but it entails no more risk.

The combined abdominoperineal type of operation is frequently advocated as the procedure of choice for the removal of lesions of the pelvic portion of the colon; first, because it affords an opportunity for radical extirpation, and second, because it obviates the hazard inherent in segmental resection with anastomosis, i.e., the possibility of impairment of the blood supply to the ends of the proximal and distal segments of the colon. The combined type of operation necessitates creation of a colonic stoma of a permanent nature, which is always objectionable to the patient. Although a permanent colonic stoma is not the curse that it is many times thought to be, whenever possible, creation of an

artificial anus should be avoided. It is not a pleasant task for a surgeon to inform the patient that his difficulty is malignancy of

is present, particularly if the cancer is of high grade and in a young individual. I do believe, however, that the procedure has

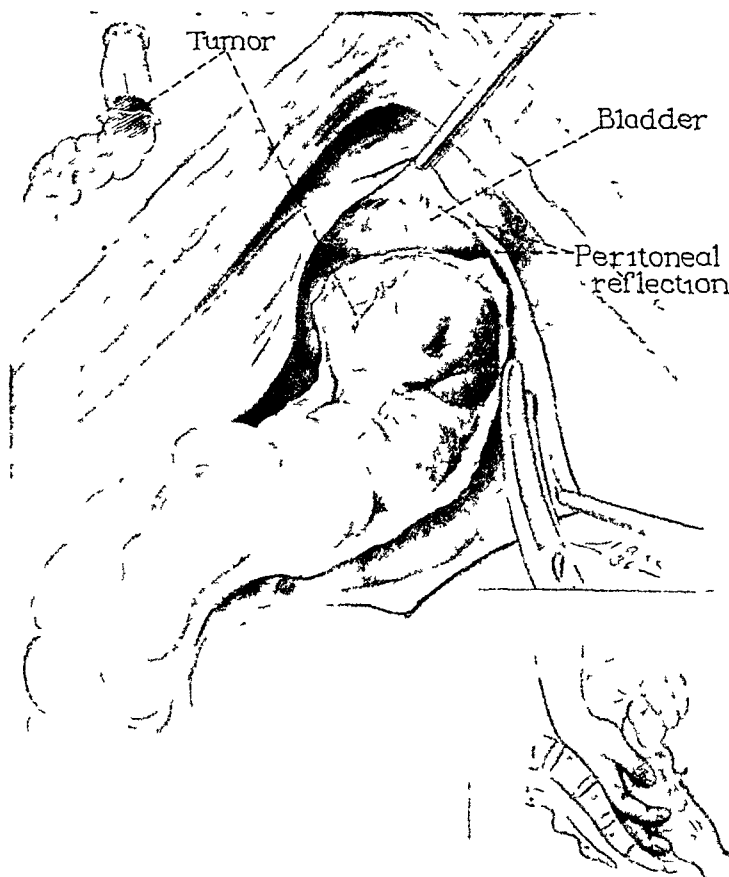


FIG. 1. Freeing of pelvic portion of peritoneum on the lateral and mesial sides of the sigmoid.\*

the lower portion of the colon or of the rectum, and that the procedure necessary is an opening in the abdomen through which his bowel will be evacuated and that the rectum will be removed, for such patients receive an explanation which is doubly disheartening. First, many no doubt believed their trouble to have been due to the presence of hemorrhoids. They are at least slightly shocked when told the disturbance is of a much more serious nature than hemorrhoids. Then, as they attempt to recover from the first shock, they are informed that creation of a permanent colonic stoma is imperative.

An abdominoperineal or perineo-abdominal operation is, in my opinion, necessary in certain instances; for example, when a lesion of the upper portion of the rectum

been employed in many cases in which the following method could have been utilized.

During the past seven years I have been performing an operation which avoids creation of a permanent colonic stoma in cases in which it is necessary to resect part or all of the pelvic portion of the colon because of the presence of a malignant process. In order to remove a lesion occurring at or just proximal to the pelvic peritoneal fold in a radical manner and make an anastomosis, it is necessary to sacrifice the superior hemorrhoidal vessels, beginning at their site of origin by removal of gland-bearing tissue from the hollow of

\* Illustrations from "Treatment of Cancer and Allied Diseases," edited by George T. Pack and Edward M. Livingston (Hoeber).

the sacrum, as is done in the combined abdominoperineal operation. It has often been stated that sacrifice of the hemor-

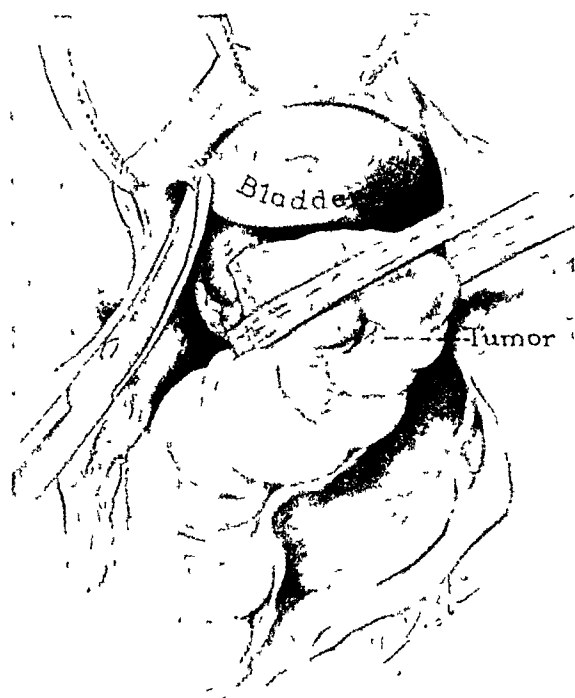


FIG. 2. The sigmoid has been mobilized by freeing it from the tissues of the hollow of the sacrum.

rhoidal vessels will cause necrosis of the rectosigmoid and rectum, but such has not been my experience. The method which I have employed permits removal of a part or all of the pelvic portion of the colon in a radical manner without permanent interference with the continuity between rectum and sigmoid; in other words, formation of a permanent colonic stoma is avoided. The technique which I have employed does necessitate emphasis on certain principles if satisfactory results and a low mortality are to be obtained. Nor is this operation set forth as a new procedure, but rather as a rejuvenation of the plan of segmental resection of the pelvic portion of the colon with reestablishment of continuity, as described many years ago by Sir Rutherford Morrison and later by Balfour. In brief, their method consisted in removal of the diseased segment of bowel without preliminary colostomy. Anastomosis was made around a tube, one end of which had been passed upward through the lumen of the

rectum into the proximal segment of the colon, this tube being held in place by tightly applied ligatures, which encompassed the proximal portion of the bowel and tube. Then the end of the tube protruding from the anus was drawn downward sufficiently to cause slight intussusception of the cut ends of the bowel, after which sutures were applied. The tube was allowed to remain in place for several days, usually eight to twelve.

The type of operation which I carry out has been employed for the eradication of lesions situated in the rectosigmoid, at or near the pelvic peritoneal floor, where obviously any type of exteriorization procedure is impossible. In practically all instances, the procedure is effected in stages. First, a low midline incision is made for the purpose of exploration. If the first portion of the sigmoid and its mesentery are sufficiently mobile, a left iliac stab wound is made and a knuckle of descending colon is brought out through the incision for the purpose of making a temporary colonic stoma. In many instances I have found it more practicable to make a small stab wound in the midline in the upper abdomen, and to exteriorize a small segment of the transverse colon to provide a temporary colonic stoma.

The second stage of the operation is performed after two or three weeks have elapsed, and at this time the low midline approach is again utilized. The peritoneal reflection of the pelvic mesocolon is incised, beginning mesially at the level of the origin of the superior hemorrhoidal vessels and then laterally, beginning 4 to 6 inches (10 to 15 cm.) above the level of the superior iliac crest. Next, the peritoneal incisions are extended downward to the pelvic floor to meet horizontally across the base of the bladder in males or the posterior aspect of the cervix in females. (Figs. 1 and 2.) The ureters are identified and isolated. Then the superior hemorrhoidal vessels are ligated near their site of origin. Care must be exercised that the ligature is placed distal to the origin of the sigmoidal

arteries. Should ligation be carried out above the origin of the sigmoidal vessels, impairment of the circulation to the

leaves to the sides of the proximal segment of the colon, forming a reconstructed and more shallow pelvis than was present

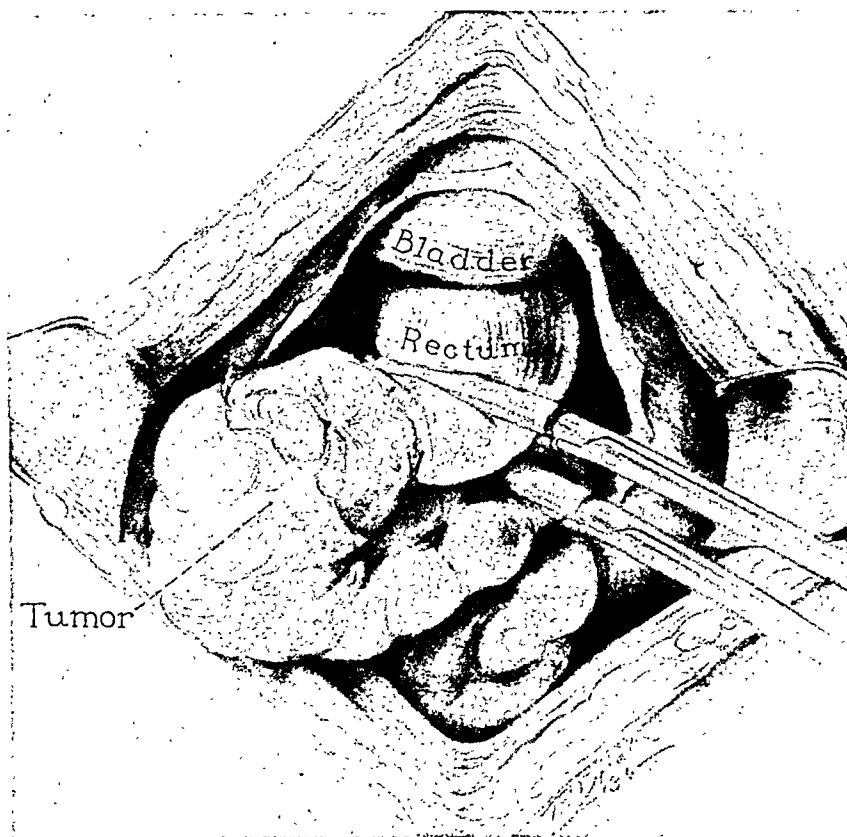


FIG. 3. The mobilized diseased segment, clamps applied, ready for removal.

proximal segment of bowel is likely to occur. The entire pelvic portion of the colon is now mobilized by manual elevation of the gland-bearing tissues from the hollow of the sacrum. Rubber-guarded (half-circle) clamps are applied and amputation of the diseased segment is carried out. (Fig. 3.) Next, an end-to-end anastomosis is made between the first portion of the sigmoid or the lower end of the descending colon and the upper end of the rectum or rectosigmoid, depending on the extent of the resection. (Fig. 4.)

As has been implied, the blood supply to the proximal portion of the anastomosis comes from the inferior mesenteric and sigmoidal vessels, whereas the blood supply to the distal segment (rectum) is maintained through the middle and inferior hemorrhoidal vessels. The next step is to approximate and suture the peritoneal

before. Almost invariably, the line of suture of the anastomosis is situated below the peritoneum. A Penrose cigarette drain is used, one end of which is passed through the newly constructed peritoneal floor into the hollow of the sacrum and the other is brought out suprapubically. In the majority of cases the colonic stoma is closed after a lapse of three or four weeks following resection.

The procedure just described seems to me to be as radical in nature as the combined abdominoperineal operation, with the exception that the rectum, and in some instances a small portion of the lower sigmoid, is preserved. Many cases have been observed in which an anterior resection of the sigmoid was done because of the presence of a malignant process, using the proximal end of the descending colon for a permanent single-barrel colonic stoma, the

rectum being left in situ undisturbed. According to my observations, when death has intervened as the result of either

lumen of the bowel in the site of union of the segments is somewhat smaller than normal, but I have not observed a case in

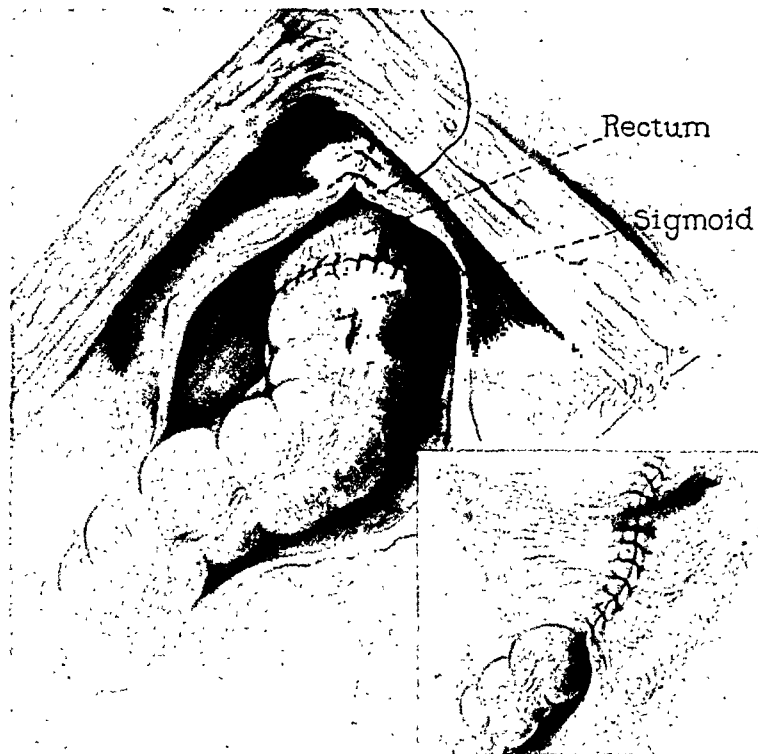


FIG. 4. End-to-end anastomosis has been completed and the pelvic peritoneum is being reconstructed in such a manner as to permit placing of the anastomosis beneath it.

recurrence or metastasis, involvement of the rectal segment has been strikingly infrequent. This emphasizes again a feature generally recognized, namely, that the spread of malignancy of the colon is, for the most part, upward in the direction of the return blood flow, and therefore, it seems justifiable to preserve the rectum and utilize its function whenever possible. A short mesosigmoid is a definite disadvantage in carrying out segmental resection of the pelvic portion of the colon with reestablishment of continuity of the intestinal tract. Marked fixation of the rectum and rectosigmoid also adds to the difficulty of technical performance.

During the past seven years I have carried out more than 100 operations of this type. Not infrequently the anastomosis can be felt upon digital examination of the rectum. In the majority of instances, the

which narrowing of the lumen was of such degree that closure of the colonic stoma seemed inadvisable. In three cases subsequent colostomy was necessary because of recurrence of malignancy in the pelvis, causing obstruction of the colon. In these instances small malignant tubercles were present over the pelvic peritoneum at the time of resection and, even though radical measures were carried out to remove these tubercles, it was realized that the procedure would, most likely, be only of a palliative nature. In two cases, two years or more elapsed before recurrence was evident; in one, less than a year passed before obstruction again occurred in the lower part of the colon. The procedure carried out in this small group of cases seemed justified because there was no evidence of malignant involvement of the liver. The most grateful postoperative patients I know are those for

whom resection of a portion of the colon has been carried out with reestablishment of continuity of the bowel. The colotomy so necessary as a first-stage procedure has allowed them the opportunity of experiencing the presence of an artificial anus.

An operation similar to the one herein described has been carried out through the perineum by Babcock and others. In that procedure, the pelvic and lower descending segments of the colon are mobilized; then, through the perineum, an incision extending from the tip of the coccyx to the anus is made, the mobilized diseased loop of bowel is withdrawn, a segmental resection is performed and an end-to-end anastomosis is established. The difficulty of this procedure, I believe, is that the convalescence is markedly prolonged, and because of the perineal incision, the nerve supply to the

sphincteric mechanism of the rectum is frequently extensively damaged.

#### CONCLUSIONS

The risk entailed in the operation I have employed is appreciable but the mortality is lower than that accompanying the combined abdominoperineal operation. I believe the reasons existing for performing anterior segmental resection of the rectosigmoid and sigmoid with reestablishment of continuity of the bowel are sufficiently sound to warrant its application in many of the cases in which the combined operation with creation of a permanent colonic stoma, is employed. Beyond all question the procedure I have described herein is far more acceptable to the patient, and probably it is actually as effective as the combined procedure, which is generally considered to be more radical.



# CANCER OF THE RECTUM AND RECTOSIGMOID: DIAGNOSIS AND TREATMENT

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THE late Daniel Fisk Jones truly stated "There is no disease that can be diagnosticated with more accuracy than cancer of the rectum after the patient once presents himself, and yet there are few diseases which are diagnosticated so late in their course." He might well have added, especially since he was to so great an extent responsible for the change, that there are few diseases for which the prospects of cure have so markedly increased in the past two decades as for carcinoma of the rectum. This progress has not been in the realm of surgical technique alone, but includes also a tremendous advancement made in roentgenologic technique, more meticulous coöperative preparatory efforts, refinements in anesthetic methods, and a recognition of the significant part played by adenomatous polyps in the genesis of carcinomas of the large intestine.

The problems involved in arriving at a diagnosis of carcinoma of the distal segment of colon and rectum are not dissimilar to those surrounding ulcer of the stomach and duodenum. Seldom is an attempt made from the anamnesis alone to differentiate between the two. A preliminary diagnosis of peptic ulcer serves the purpose of indicating the probable existence of an organic lesion in the upper gastrointestinal tract, the exact nature and location of which can be determined conclusively only through roentgenologic studies. Similarly the colonic syndrome of organic disease—rectal bleeding and altered bowel habit—should be universally accepted as an indication for a painstaking investigation of the lower gastrointestinal tract, including digital, sigmoidoscopic and radiologic examinations, for there are no symp-

toms that one might designate as being pathognomonic.

Blood, usually bright to dark red, mixed with the stool or appearing as simple streaks on it, or in varying quantities with discharges of mucus and small flakes of fecal material, may have as its origin a malignant lesion of the left half of the colon or the rectum, or hemorrhoids, or diverticula of the colon, or benign polyps, or benign ulcers. Yet, since bright blood is almost universally recognized as the most significant first indication of cancer of the rectum, physicians would do well to assume the probable existence of malignancy in every patient who reports such a finding. It is our confirmed belief that almost every patient, if not all of them, in whom a diagnosis of cancer of the rectum has been made passes bright blood at stool. Bleeding had been noted by the patients in 78 to 89.5 per cent of series of cases reported by Rosser, Brindley, Buie, and by one of us (Rankin). Browne recently stated that in the rectal cases of his series it was universal. Similarly, one of us (Graham) has been able to obtain evidence of rectal bleeding in all of his most recent thirty-eight cases diagnosed carcinoma of the rectum or sigmoid. It is significant to note, however, that only 78 per cent of these patients themselves had noted blood at stool when first questioned. The observation in the remaining 12 per cent was made by members of the hospital staff. To the usual question "Have you ever passed bright blood at stool?" the patient not infrequently answers "no." Yet to the next question "Do you ever observe the passages from your bowel?" The answer is just as frequently "no." The inconsistency of

such answers long ago led us to require patients whose complaints suggested disease of the large intestine, to observe carefully their stools or to enter the hospital that we might make such observations.

Constipation, persistent in character and progressive in degree, may be the result of altered metabolic processes accompanied by progressive atony of the musculature of the colon, or it may be due to pelvic pathology such as a gradually enlarging, retrodisplaced uterus or ovarian cyst, or external constriction of the pelvic colon produced by an endometrial growth, or to many and varied conditions among which is carcinoma of the rectum. Patients, however, attach less significance to such disorders than to bleeding and are prone to temporize with increasing constipation or diarrhea until tenesmus and abdominal discomfort influence them to consult a physician. It will be noted from the following excellent description of a slow, progressing, constricting cancer of the rectum, written in 1810 by Thomas Copeland, that 130 years have not altered the basic problems involved in arriving at a diagnosis of cancer of the rectum:

"The first symptom of the disease is an habitual costiveness; but this is so frequent in occurrence and produced in so many ways that it is not likely that the cause should be sought for in an organic affection of the rectum. Mild purgation is resorted to, and the symptoms being relieved, the cause is no longer sought after. When this has subsided for some time the patient complains of what is called piles, and what is often really so, as a consequence of obstructed circulation in the parts."

In a series of cases of cancer of the colon reported by one of us (Rankin), constipation was the predominant complaint in 332, or 55 per cent. Rosser in a similar series of cases reported an incidence of 61 per cent.

Diarrhea is encountered in a great variety of disorders, such as achlorhydria, colitis, dysentery, congenital adenomatosis, and in carcinoma of the large intestine,

particularly of the rectosigmoid, as the lumen of the bowel becomes encroached upon. Diarrhea was the cardinal complaint in 22 per cent of Rosser's cases of cancer of the rectum, in 20 per cent of a series reported by one of us (Graham). In these two series the complaint of diarrhea led to a diagnosis of dysentery or colitis in 17 per cent and 15 per cent of the cases, respectively.

The terms "constipation" and "diarrhea" are a source of considerable confusion during the process of questioning the patient. The direct question as to the number of stools each day may or may not elicit this information satisfactorily. These patients will often deny constipation, notwithstanding the daily intake of large doses of purgative medicine necessitated by their inability satisfactorily to relieve themselves by defecation. Consequently the usual simple question, "Do you have a daily bowel action?" or "How often do your bowels move?" are inadequate. In denying constipation the patient will frequently state that to the contrary they suffer from diarrhea. When diarrhea is the prevailing symptom, however, the history may be misleading, as the average patient is likely to consider anything diarrhea from a frequent desire to go to stool to ten or more large, watery stools a day. Actually, diarrhea seldom occurs. These frequent movements often consist only of a minimum quantity of water matter, mucus, and probably blood, and represent the so-called compensatory or pseudodiarrhea which manifests itself in the face of almost complete obstruction. Careful questioning of patients will often elicit a history of a preceding protracted constipation for which they resorted to energetic purgation. We have been forcibly impressed with the considerable number of patients who have been treated over long periods of time for amebic dysentery, chronic ulcerative colitis and other disorders in the course of which have been administered yatren, stovarsal, emetine, Barger's specific vaccine and serum and sulfanilamide—to mention just



a few forms of medication employed—and who have been subjected to so-called high colonic irrigations consisting of a great variety of antiseptic solutions. Yet in almost every instance an annular growth could be felt with the examining finger, while the remainder were readily visualized through the proctoscope. Moreover, inspection of the rectal discharges of these patients by ourselves or by experienced assistants, which is our invariable practice in such cases, has demonstrated that in a majority of instances the quantity of the individual passages rarely exceeded half an ounce and that the amount of fecal material expelled in twenty-four hours seldom totalled 1 ounce. The bulk of the material passed was mucus.

The so-called ribbon stools possess no significance as regards carcinoma of the rectum. They depend upon the tonicity of the anal sphincters and are seen in cases of constipation more often than in cases of organic disease.

Severe pain is seldom a prominent symptom until the malignancy is far advanced or the anal canal, which alone is endowed with pain sensation, is involved. Moderate degrees of pain not infrequently are associated with ineffectual peristaltic activity and the accumulation of gas in instances of a markedly stenosed bowel lumen, particularly at the rectosigmoid. Excessive loss of weight and strength seldom are encountered in patients in whom the rectal lesion is operable. Fifty-six per cent of 300 cases studied by Rankin and Jones were of normal weight or obese at the time of examination, which averaged eleven and seven-tenths months after the onset of symptoms.

Although marked secondary anemia is of rare occurrence in instances of carcinoma of the rectum (Rankin and Jones reported an average hemoglobin reading of 72 per cent in their series of 300 operable cases), a wide variation in the hemoglobin reading will be noted in individual cases. Moreover, in determining operability or prognosis very little significance can be attached to

readings of the hemoglobin. Illustrative of this fact is the following experience of one of us (Graham) with five consecutive cases simultaneously hospitalized. Case I, weight normal, hemoglobin 96 per cent, inoperable because of glandular and hepatic metastasis; Case II, 24-pound weight loss, hemoglobin 72 per cent, definitely operable; Case III, weight normal, hemoglobin 102 per cent, glandular involvement, died nine months after palliative resection; Case IV, recent gain in weight, numerous moderate rectal hemorrhages, hemoglobin 106 per cent, operable; Case V, 30 pound loss in weight, numerous moderate rectal hemorrhages, hemoglobin 76 per cent, definitely operable. The determinations of hemoglobin were all carried out in the same laboratory by trained technicians and by one of the more accurate methods. It is quite evident that repeated hemorrhages in one instance produced secondary anemia and in another stimulated the production of hemoglobin.

In the final analysis the diagnosis will depend on a careful examination of the patient by methods available to every physician, namely digital examination and proctoscopic visualization of the rectum and rectosigmoid.

#### TREATMENT

When one has established an accurate diagnosis of cancer of the lower gastrointestinal tract, the question of treatment demands, first, an evaluation of the types of therapeutic agents at hand, and second, a decision as to whether radical or palliative measures shall be adopted. By and large, it is now accepted that radical surgery in operable cases of cancer of the rectum is the procedure of choice among curative maneuvers. True, in the aged, poor surgical risks, and in certain pathologic types of growths readily accessible to local treatment, diathermy occasionally is useful. Radium has its place in the treatment of malignancy in this location because it can eradicate certain types of lower rectal growths without sacrifice of the

sphincteric mechanism, and can occasionally convert an advanced, fixed, inoperable growth into an operable tumor, or if the growth has not metastasized when destroyed, even effect an occasional cure. That the power of radium, however, is variable and controlled with difficulty, is well known, and the dangers in its use make it an unsuitable agent for general employment and safe only in the hands of experienced operators. Coöperation between surgeons and radiologists unquestionably will in the near future more accurately evaluate its place, but at the present time it seems a fair position to take that radium has a very small field of applicability in the operable group of rectal and rectosigmoidal cancers.

Surgery then, is the agent of choice and its limitations are fairly rigidly established. Operability curves and secondarily mortality figures are influenced, first, by the location, mobility, and extent of the growth; second, by the presence of obstruction; third, by the presence or absence of metastases; and fourth, by the age, general condition and presence or absence of concurrent debilitating diseases.

Palliative measures usually are confined to decompressive procedures. Obstruction, which is present in the vast majority of cancers of the rectum of any long standing, plus fixation and general debility, call for colostomy or cecostomy. The question of resection in the face of hepatic metastases is a difficult problem to decide. Death from intestinal cancer, which has progressed to fixation, attachment to other viscera, invasion of neurogenic elements, and obstruction, is a most unpleasant and painful demise. On the other hand, the liver may be filled with cancer, hepatic function diminished, physiologic equilibrium undermined, and the individual die comfortably from weakness and asthenia but without pain, if the original growth is removed. In consequence, it oftentimes is justifiable to remove a growth which is operable but which has metastasized, if the removal can be done with a mortality figure acceptable for

operable cases. The decision to do any type of operation, and particularly a palliative operation, should be regulated by the dictum that the risk of the operation should not be greater than the risk of the disease.

*Obstruction.* Intestinal obstruction from left colonic and rectosigmoidal growths is a common occurrence. One would expect this when it is remembered that the tumors in this location of the bowel frequently are encircling, that the anatomic conformity of the bowel is narrower and more muscular than in the rest of the colon, and that the content of the bowel is solid, formed fecal material; that the sigmoid enters the top of the rectum at the rectosigmoid juncture at an angulation and that the rectosigmoid juncture usually is a fixed anatomic segment without mesentery. The group of acute intestinal obstruction cases found in the left colon and the rectosigmoid represents somewhere between one-fourth and one-half of the whole group of cancers of the left colon and rectum.

Often obstruction appears out of a clear sky, the individuals are rushed into the hospital with a diagnosis of acute intestinal obstruction without cancer being suspected, and operative decompression after attempts at medical relief become imperative. In this connection, it has seemed useful to us to use blind cecostomy done through a right McBurney incision under local anesthesia.

It may be mentioned in passing that immediate decompression by cecostomy often is a difficult procedure because of the local conditions and that the technique of performance of this operation differs materially from that utilized when it is employed as a complementary procedure. The cecum, under conditions of acute intestinal obstruction may be, and frequently is hugely distended, half filled with liquid feces, and apparently almost at the bursting point from pressure of intracolonic gases. Such an organ does not lend itself readily to manipulation without danger of rupture, and efforts to suture this type of

bowel often result in decompression, for sooner or later the needle point will enter the lumen and a whistle of gas announces the accident to the surgeon. It is better under such circumstances to seal off the anterior bowel wall with packs, deliberately puncture the cecum with a needle and allow the gas to escape. Then one may either deliver the cecum outside the wall, put a tube under it, and suture it to the peritoneum or introduce a large rubber tube after Witzel's technique.

When one eliminates colonic obstruction and confines the group to rectal cancers, the utility of cecostomy is still obvious. Most rectosigmoidal cancers produce obstruction, either chronic, subacute or acute, during the time of their presence. This obstruction usually can be relieved preoperatively by medical management, but not infrequently at exploration the surgeon finds a thickened, hypertrophied bowel proximal to the growth, surrounded by multiple telangiectases, enlarged lymphatics and with edematous tissues in the mesentery which indicate that the stenosis is not completely relieved. Under such circumstances, a cecostomy performed as above is a desirable first stage of a graded procedure. Whipple, in 1931, reported a number of cases done by this method as a deliberate first stage of graded operations for graver risks, and our own experience in a number of instances where decompression had not been adequately accomplished prior to exploration, has convinced us of its utility and the satisfaction of its employment. Employing cecostomy under these circumstances, one relieves the obstruction, drains the bowel, and places the stoma as far away from the midline as possible to advantage subsequent resection.

For these reasons it is more useful than colostomy under certain circumstances, and although it may require an operative procedure for closure, such an operation may usually be carried out under local anesthesia and with small discomfort to the patient and no additional loss of time in the hospital.

*Choice of Operation.* Many factors enter the choice of a technical procedure, such as the skill, judgment, boldness and personal prejudices of the surgeon and the estimation of the patient's ability to undergo surgery up to a certain limit. Individualization of patients by fitting them into the proper type of operation at exploration influences the final decision in selection. Happily there is no longer any disagreement as to the desirability of certain fundamental principles in all cases brought to operation after careful scrutiny. Radical removal of the offending growth with block dissection of the adjacent gland-bearing tissues, and secondary acceptance of colostomy as a necessary part of such a maneuver, no longer are questioned as essential features of the offensive. There still remain a few surgeons who for one reason or another advocate, in print at least, segmental resection or anterior resection with subsequent reestablishment of the gastrointestinal continuity; or posterior exteriorization procedures, or some other novel type of operation which saves the sphincter muscle, but in the main the surgical world rarely dissents from the dictum that a colostomy is a necessary part of any radical curative operation for cancer of the rectum. It is unfortunately true that the general practitioner who first sees cancer of the rectum and either makes or suspects the diagnosis, is far from being universally convinced of the necessity or desirability of this step.

The technique of manufacture of a colostomy has advanced markedly in the last quarter of a century and nowadays a properly made stoma need give the patient small room for complaint save during attacks of diarrhea. A better understanding of diet and a more thorough knowledge of the proper method of handling the colostomy have done away with many of the objections to its employment and it is now widely recognized that the possessor of an artificial anterior anus no longer need suffer social ostracism or professional incapacity.

The location of the growth exerts an important influence in the selection of operation because two out of three rectal cancers are either high in the rectum or low in the sigmoid. Approximately 66 per cent of the whole group are within an inch of the peritoneal reflection either intraperitoneally or extraperitoneally. Thus it becomes increasingly apparent that only an operation which will remove tissues in all the zones of spread and particularly in the upward zone, namely, the mesentery of the sigmoid, can be employed to eradicate the malignancy in a high percentage of cases. One other factor which should exert an enormous influence toward the selection of the radical combined procedure in any case to which it may be applied with reasonable satisfaction, is the factor of glandular involvement. More meticulous methods of searching for cancer cells in resected specimens have proved beyond doubt that a huge percentage of cancers of the rectum have already metastasized at the time of operation. Ten years or more ago Broders and Rankin reported on the glandular metastases in 300 cases of cancer of the rectum and found involvement in 45 per cent. More recently Gabriel, Dukes and Bussy at Saint Mark's hospital have reported a series of resected specimens showing 65 per cent of involved glands. In May, 1938 David and Gilchrist before the American Surgical Association reported a series of cases of cancer of the rectum in which 68 per cent of the resected specimens showed glandular involvement. This rising curve of glandular metastases is the result of more painstaking and meticulous methods of examination.

It is axiomatic that no one procedure will ever be applicable to all types of cancer in this location, particularly since patients present themselves in various stages of the disease and in different physical states. However, increasing experience buttressed by statistical studies indubitably indicates that radical extirpative maneuvers either in one or several stages which eliminate the local growth and contiguous tissues, sacri-

ficing a large part of the mesentery of the sigmoid and establishing a colostomy, are preferable to other varieties when they are acceptable under tests of modern operability.

The choice of operation in the average case of cancer of the rectum lies between: (1) combined abdominoperineal, or perineo-abdominal resection in one or two stages; and (2) Lockhart-Mummery's operation of colostomy and posterior resection. Numerous other procedures are advocated, varying from perineal excision with perineal colostomy or segmental resection with or without preservation of the sphincter, to local excision, but by and large their popularity has not been extensive. The present day attitude toward the combined operation has come about because of the reduction of mortality to a plane comparable with that of the less radical procedures. It is hardly likely that so formidable a procedure as a combined resection of the rectum, either in one or more stages will ever become routine and safe in the hands of casual operators, but in this day of specialization more and more general surgeons have mastered its technique and coupled this experience with a meticulous preoperative preparation and postoperative care period to a point where it may be used advantageously and widely. Unquestionably there is a wide field of usefulness for the operations of both Miles and Lockhart-Mummery.

*Mortality and Operability.* Operability curves and mortality figures and data on end results are inextricably interwoven, for the ultimate outcome following surgery depends upon both the radicalness of the operation and the time at which it is done. Operability or resectability has a most important bearing upon hospital death rates as well as prognosis, for an operable case in one surgeon's hands may be abandoned entirely or treated with a palliative side-tracking operation by another less bold or less experienced. In the hands of mature, trained surgeons, operability is limited largely by: (1) hepatic metastasis;

(2) fixation of the growth; and (3) general systemic conditions affecting the individual's resistance to surgery. The latter, termed "extrinsic" influences, must be well weighed in accepting for radical surgery a debilitated individual; cases with hepatic metastasis must be placed in a separate category. By and large, it is a fair rule to accept for resection all patients with growths not immovably fixed, or requiring double resections or otherwise complicated by perforation, abscess formation, etc. To give to the greatest number of patients a chance to recover from cancer by surgery, makes it necessary to extend the limits of operability to a point where they include the borderline cases and occasionally an inoperable case which has metastasized to the liver but is still locally removable, with a reasonable risk.

It is a very noticeable fact gleaned from a study of statistics over the past two decades that in the hands of all surgeons experienced in this type of surgery, the resectability rate is steadily rising. At the Saint Mark's Hospital, Gabriel reported a series of cases operated upon over the years of 1910-1920, finding 41.6 per cent to be operable. The next decade from 1921-1931 saw the operability rate rise to 54 per cent. In our service the operability rate of around 50 per cent prior to 1930, had by 1935 risen to 74.8 per cent. This has been the experience of other surgeons both upon the Continent and in America, and represents a laudable attempt to apply radical surgery to cancer of the rectum, keeping within compatible bounds the hospital death rate.

Mortality following resection for cancer of the rectum is influenced not only by the selection of cases for operation, but also by the type of surgery employed. It goes without saying that the more formidable "combined" operations, whether in one or two stages, carry a higher mortality rate than the less radical perineal excisions. Nevertheless, it is provable statistically that in the hands of experienced surgeons the difference in mortality rate is compara-

tively small and the argument may also be advanced that the advantages over a term of years which accrue to the patients upon whom the more radical procedures are done, far outweigh the smaller hospital death rate. In 1933, Lockhart-Mummery reported on 300 consecutive cases of perineal excision by his method, having a mortality of 7 per cent. D. F. Jones reported a mortality for the combined operation in 136 private cases, of 12.5 per cent. T. E. Jones, in a group of 151 one-stage combined operations, had a mortality of 7.2 per cent with an operability rate of 63 per cent. Table I from the service of one of us (Rankin) shows not only the resectability rate in a series of 191 cases but also the choice of operation and the operative mortality. From this table it is evident

TABLE I

	Cases	Deaths	Per Cent Mortality
One-stage combined resection	99	7	7.07
Colostomy and posterior resection	38	3	7.8
Colostomy alone or with exploration	35	6	17
Exploration alone	10	0	
Two-stage combined	06	0	
Cecostomy (acute obst. due to ca.)	03	1	
	191	17	
Patients	191		
Operations	234		
Resections	143		
Resectability		74.8 per cent	
Mortality		8.9 per cent	

that the trend toward radical operation in one-stage has been carried out in two-thirds of the cases. Moreover it is interesting to note that there is slight difference between the mortality of the one-stage combined operation and colostomy and posterior resection in this series. The resectability rate of 75 per cent represents an horizon of operability which, although desirable to maintain, may not prove routinely feasible. It is difficult to evaluate the factors

influencing prognosis without entering into considerable detail, but consonant with the trend toward more radical surgery one finds five year cures increasing in proportion to the application of formidable maneuvers and favorably influenced by early diagnosis. When it is realized that five year cures from sphincter saving operations are approximately 33 per cent, whereas the more radical procedure of one-stage combined abdominoperineal (Abel) shows 63.4 per cent, it becomes increasingly apparent where the advantage lies. Yet common sense and good judgment indicate that between these two extremes lies a large group of cases which must be done by other well selected types of operation, and which will show an average of between 40 and 50 per cent of five year cures. While unquestionably great strides have been made in the past two decades in the surgical treatment of rectal cancer and while one may view with optimism the progress

toward the more radical treatment and better end results, it must be recognized that the problem still remains a vastly important one which demands the combined best efforts of practitioner, pathologist, and surgeons.

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# THE PROBLEM OF THE SURGICAL TREATMENT OF CANCER OF THE RECTUM

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AN operation undertaken for the eradication of cancer must be based on pathologic findings in regard to the spread of cancer cells to surrounding tissues from the primary growth. If the operative field is not sufficiently extensive to embrace the whole of the tissues that are known pathologically to be prone to invasion by cancer elements which have become detached from the primary focus, then the operation will be doomed to failure, because it will not prevent recurrence.

The whole question, therefore of the operative treatment of cancer of the rectum hinges upon the knowledge, first of the manner in which cancer of the rectum spreads, and secondly, of the paths along which that spread takes place.

## THE SPREAD OF CANCER OF THE RECTUM

As the result of (1) noting the position of metastases in the extramural tissues during the performance of primary operations; (2) observing the structures that were the site of metastases during the performance of secondary operations; (3) recording the extent and the position of metastases in cases in which a proposed operation had to be abandoned on account of their existence; (4) studying the post-mortem findings in regard to the spread of cancer in those who had died from advanced and inoperable cancer, and (5) by the minute dissection of specimens removed by operation, I was enabled, in a paper read at the meeting of the British Medical Association in 1910, to point out that during the process of growth cancer of the rectum spreads in three distinct ways: (a) by direct extension through continuity of tissue;

(b) through the venous system; and (c) by means of the lymphatic system.

*Direct Extension through Continuity of Tissue.* This takes place in two directions: (1) on the mucous surface of the bowel progressively from its entire margin, and (2) through the thickness of the bowel wall. The marginal increase is generally greater and more rapid in the transverse direction than in the longitudinal axis of the bowel. It is not uncommon to find that, whereas nearly the whole of the circumference of the ampulla has been invaded, the extent of the growth longitudinally is less than 2 inches. The growing edge undermines the more normal mucous membrane extending in the submucous tissue deep to the muscularis mucosae. Such surface extension is comparatively slow: thus, in the ampulla, for instance, it will take about six months for the growth to travel round a quarter of the circumference in an average case. While surface extension is slowly progressing, the more important deep infiltration of the muscular coat of the bowel is taking place, and appears to be a slow process.

When the bowel wall has been penetrated the growth invades the perirectal fat, through which it extends until it reaches the fascia propria of the rectum. According to my observations upon this point the fascia propria is not usually penetrated until the disease has existed long enough for more than three-quarters of the ampulla to have been encompassed, thus indicating that it has been in existence for about eighteen months. It is only after penetration of the fascia propria that invasion of neighbouring structures such as the sacrum, uterus or vagina, prostate or bladder

can take place; and it would seem that involvement of adjacent structures by direct extension does not occur until the expiration of at least a year after the initial appearance of objective symptoms. It will be seen, therefore, that the mode of spread through continuity of tissue is a comparatively slow process, and that direct invasion of neighboring structures does not take place until the growth in the rectum has involved the greater part of the circumference of the bowel.

If extension of cancer through continuity of tissue were the only or even the usual mode of spread from the rectum, the surgical treatment of the disease would be quite simple, because, unless the growth has extended beyond the confines of the fascia propria, a restricted operation, entailing nothing but the removal of the portion of the musculomembranous tube containing the cancer in its interior, would be all that was necessary to rid the patient completely of his disease. Unfortunately however, other and more important modes of spread take place simultaneously and with greater rapidity, leading to distant dissemination even when the primary growth is still in an early phase of development.

*Through the Venous System.* There is no doubt whatever that cancer cells sometimes penetrate into the interior of small veins and becoming detached are carried in the blood stream. The actual invasion of a venous radical is occasionally seen in microscopic sections of carcinomatous tumors. As the rectal veins belong to the portal system, cancer cells penetrating them are carried straight to the liver. The metastasis thus produced by an embolus of cancer cells is single and is usually situated in the middle of the right lobe of the liver. It is fortunate that dissemination by the veins is very rarely encountered, so that in practice we can disregard the possibility of its occurrence.

*By Means of the Lymphatic System.* Infinitely more important is the dissemination of cancer cells through the lymphatic channels, and a knowledge of the lymphatic

system is essential to the performance of any radical operation on cancer.

#### ANATOMY OF THE LYMPHATICS OF THE RECTUM

The rectal lymphatics are arranged in three groups, intramural, intermediary and extramural.

1. The intramural lymphatics are contained in the wall of the rectum and consist of two distinct networks, one situated in the submucous tissue and the other between the muscular layers. The two networks communicate freely with one another by means of short radial channels which pass through the circular muscular coat. The submucous network of the ampulla is continuous above with that of the pelvic colon and below with a similar network in the anal canal. The latter is also in communication with the lymph plexus in the subcutaneous tissue of the perianal skin, from which collecting stems pass forward, in the furrow between the perineum and the inner aspect of the thigh, to terminate in the innermost of the horizontal set of inguinal glands. The intermuscular network of the rectum communicates above with that of the pelvic colon and below with the lymphatics of the external sphincter muscle. The collecting stems traverse the external muscular coat of the rectum and terminate in the lymph channels of the intermediary system.

2. The intermediary lymphatic system consists of two parts, namely, a subserous network in the portion of the rectum which is covered by peritoneum, and a lymph sinus, situated between the external muscular coat and the perirectal fat in that part of the rectum which does not possess a peritoneal investment. The lymph sinus can always be demonstrated in any specimen of the rectum which retains its coverings of perirectal fat. It is not a free space, but is occupied by a delicate wide-meshed reticulum consisting of fine strands of connective tissue. It is possible that the connecting stems from the intermuscular network, after traversing the external coat,



empty themselves directly into this lymph sinus instead of passing across it.

3. The extramural lymphatic system is the most important of the three. The collecting stems from the lymph sinus form an extensive plexus and enter into relation with the anorectal glands of Gerota, which are scattered over the surface of the rectum among the branches of the superior hemorrhoidal vessels. The efferents from this plexus and from the anorectal glands pass to their ultimate destination in three directions, namely, downward, laterally, and upward.

The downward efferents traverse the fatty tissue of the ischiorectal fossa in company with the inferior hemorrhoidal vessels, enter into relation with a small group of lymph nodes situated close to the exit of Alcock's canal, then pass through the canal and empty themselves into the internal iliac glands. The lateral efferents enter a plexus situated between the levator ani muscles and the pelvic fascia from which collecting vessels pass to the obturator gland, situated at the upper border of the obturator foramen. The efferents from the obturator gland pass to the internal iliac glands and to the innermost of the group of glands accompanying the external iliac vessels.

The upward main efferents accompany the superior hemorrhoidal veins, enter the lowermost mesocolic (retrorectal) glands, then accompany the inferior mesenteric vein as it lies in the parietal border of the pelvic mesocolon and finally enter the group of glands situated at the bifurcation of the left common iliac artery and also the median lumbar (aortic) glands. Some of the efferents from the uppermost part of the plexus enter into relation with the paracolic glands situated along the mesenteric border of the pelvic mesocolon, from which collecting stems accompany the sigmoidal vessels to end in the median lumbar glands.

Such being the anatomic arrangement of the lymphatics in connection with the rectum, the tissues through which the

lymphatics pass are liable to be invaded by cancer cells which have become detached from the primary growth.

The spread of cancer cells in the submucosa of the rectum is very limited and does not extend more than a few lines beyond the microscopic margin of the growth. Spread in the intermuscular lymphatics is just as limited. Both clinical and histologic observations show that the intramural spread is always of comparatively trivial extent. It is, therefore, probable that detached cancer cells pass through the bowel wall somewhat rapidly by means of the intramural lymphatic system, and having entered the external lymphatics, give rise to extramural metastases scattered over a wide area long before the muscular coat has been penetrated by direct extension of the growth.

The direction in which the cells travel is largely influenced by the direction of the current in the lymphatics which have been invaded. It must be remembered, however, that the path by which the cells advance is not entirely controlled by anatomic considerations. Thus, it may happen that cancer cells derived from a growth in the rectum, wherever situated, may traverse the lymphatics in a downward, lateral, or upward direction, or in all three directions simultaneously. During the transit their progress may be arrested at any point in the region traversed by the lymphatics and so lead to the formation of nodules. The various tissues through which the lymphatics pass, therefore, are prone to metastatic deposit, which is either macroscopic or microscopic in character. It may be regarded as an axiom that whenever a visible metastasis exists, other metastases, which cannot be recognized without the aid of the microscope, also exist along the course of the lymphatics, at points more distant from the seat of the primary growth.

There are three distinct extramural paths along which cancer cells invade the neighbouring tissues, constituting what may be termed zones of spread.

1. *The Zone of Downward Spread.* The structures comprised in this zone are the perianal skin, the ischiorectal fat and the external sphincter muscle. Owing to the free intercommunication between the lymphatics of those structures and the efferents from the rectum, it is easy to understand how the progress of a detached cancer cell may be arrested at any point in that extensive network. It is also apparent that even an exhaustive microscopic examination of the structures above mentioned might fail to detect such isolated cancer cells. Nevertheless, the presence of minute masses of cancer cells has been revealed in microscopic sections often enough to establish the fact beyond doubt that these structures are liable to be invaded during the process of dissemination.

2. *The Lateral Zone of Spread.* This area embraces the structures whose lymphatics enter into relation with the extensive lymphatic network between the levatores ani and the pelvic fascia. These structures are the levator ani muscles, the coccygei, the pelvic peritoneum, the prostate gland, the base of the bladder, the cervix uteri, the base of the left broad ligament and the internal iliac glands. The levatores ani are sometimes the seat of metastases. I have encountered them in the substance of the muscle close to its attachment to the rectum and also near its origin from the pelvic wall during the performance of excision operations, both primary and secondary. These muscles are exceedingly prone to invasion by cancer cells, which gain access to the extramural lymphatics before the deep infiltration of the primary growth has had time to penetrate the muscular coat of the bowel and they should, in all cases, be completely removed when a cancerous rectum is excised.

I have observed plaque deposits in the peritoneum of the pelvic floor upon so many occasions that it would not be an exaggeration to say there is not a portion of it, from the middle line to the brim of the true pelvis, that has not been implicated. This is no doubt due to the fact that the perito-

neum in this locality is in close relationship with the extensive lymphatic network situated between the levatores ani and the pelvic fascia. A metastatic deposit in this network, therefore, speedily penetrates the pelvic fascia and extends into the overlying peritoneum. Accordingly, it is essential that the peritoneum of the entire pelvic floor, as far as the brim of the true pelvis on both sides, should be removed in every case of extirpation of the cancerous rectum if immunity from recurrence is hoped for.

3. *The Upward Zone of Spread.* The tissues of this zone are the retrorectal (lowermost mesocolic) glands, the pelvic mesocolon in its entirety, the paracolic glands, the glands situated at the bifurcation of the left common iliac artery and the median lumbar glands.

Since the majority of the efferent lymphatics, which form the intramural lymphatic system, either pass through or terminate in the structures contained in this zone, it follows that these structures constitute the principal paths by which cancer cells spread from primary growths in the rectum. This is the most constant and, therefore, the most important of all the routes of spread. We find either macroscopic or microscopic metastases scattered throughout the zone in practically all cases of cancer of the rectum, even when the growth is in an early stage of development.

In some instances the retrorectal glands are obviously enlarged and can be readily felt, but, in the majority, though the fresh specimen is carefully palpated, it is extremely difficult to be certain whether the glands are enlarged or not. Nevertheless, when these specimens have been hardened and dissected, the involvement of the glands is evident. Moreover, microscopic examination of the glands always shows one or more of them to be invaded by cancer cells. It sometimes happens that a gland may be free from deposit although the tissues surrounding it are definitely invaded by cells. In such a case, if the glands alone were examined and found to be free from invasion, an erroneous con-

clusion as to the absence of extramural spread might be arrived at and a more hopeful prognosis, in regard to the possibility of recurrence taking place in adjacent structures, might be given than would be warranted had a more thorough examination been made.

The pelvic colon throughout its extent is particularly liable to invasion. So often, indeed, is it found to be the seat of metastatic deposit that the removal of the whole of this structure in every operable case of cancer of the rectum is just as important as is thorough clearance of the axilla in an operation for cancer of the breast.

The part of the pelvic mesocolon which is invariably invaded is its parietal border, between the layers of which the superior hemorrhoidal and the inferior mesenteric vessels are situated. The efferent lymphatics from the retrorectal glands accompany these vessels on their way to the glands located at the bifurcation of the left common iliac artery, and constitute the principal route by which cancer cells are carried from the rectum by the blood stream. At any point along this line metastases may occur, either singly or in chains. There is scarcely a part of the pelvic mesocolon in which, from time to time, I have not observed metastatic deposits so that the whole of the structure must be regarded as highly dangerous tissue.

The paracolic glands which are in series with the anorectal glands and are situated along the mesenteric border of the pelvic colon, are often the seat of metastatic deposit. The involvement of these glands does not proceed from one to the other seriatim as might be expected, for a continuous chain of infected glands is never seen. When a paracolic gland is found to be involved, it is generally isolated and may be situated at a considerable distance from the level of the primary growth. Instead of spread taking place from one paracolic gland to another, it is probable that the cancer cells first follow the course of the lymphatics accompanying the inferior mesenteric vessels, and then, owing to blockage

of the normal lymph stream by metastatic deposits, grow continuously or are carried by reversed flow along the lymphatic vessels of the pelvic mesocolon towards the colon, to be arrested in one of the paracolic glands.

When, therefore, the rectum, together with part of the pelvic colon, has been removed by a perineal method of excision, it is quite possible that an infected paracolic gland, above the level of the point of section of the bowel, may have been left behind, despite the fact that a careful examination of all the paracolic glands contained in the specimen has failed to demonstrate evidence of infection. Even the extensive removal of the pelvic colon by means of the abdominoperineal operation may sometimes fail to include an infected paracolic gland when situated many inches above the level of the primary growth.

There is ample evidence that the dissemination of cancer cells by means of the extramural lymphatic system is more widespread and of much greater consequence than that which takes place in the intramural lymphatics. Moreover, it appears that, of the three zones of possible extramural spread, the upper zone is the most important because secondary deposits are always present, either visible to the naked eye or discernible by the microscope.

From the above observations it will be seen that the ischiorectal fat, the levator ani muscles, the pelvic peritoneum and the pelvic mesocolon throughout its extent are the tissues which are chiefly concerned in the spread of cancer from the rectum. Pathology teaches us that these structures may be the seat of metastatic deposits even when the growth in the rectum is in a clinically early stage, and that unless these highly dangerous tissues are completely removed in every case in which an operation for the removal of the cancerous rectum is undertaken, postoperative recurrence will be a rule to which there will be few exceptions.

At the close of the year 1906, I abandoned perineal methods of excising the rectum because I found that they failed to prevent recurrence. The type of operation that I then performed was the most complete that it was possible to carry out by a perineal method of exposure. It failed because the tissues of the upward zone of spread which had already been invaded lay beyond the reach of any operation carried out solely from the perineum. These tissues (which would represent the axilla in cases of cancer of the breast) can only be approached from the abdomen, and therefore it is obvious that the attempt to remove the cancerous rectum from the perineum alone is as futile as amputating a breast affected by cancer without also clearing the axilla of its affected lymphatic glands.

Since January, 1907, I have consistently employed the abdominoperineal operation in all suitable cases. I planned this operation in order that the tissues comprising the upward as well as those of the downward and the lateral zones of spread could be widely removed.

Cancer of the rectum claims 100 per cent mortality if left to run its course untreated. If then, the operation undertaken for its cure is followed by a high recurrence rate surgical intervention will have failed in its object.

The operation of choice is the radical abdominoperineal, because it alone of the methods at our disposal ensures thorough removal of the tissues of the three zones of spread. It should be chosen for early cases, on the principle that the most comprehensive operation that it is possible to carry out, for the treatment of the earliest case of cancer, ensures the greatest immunity from recurrence.

The operation should not be recommended for patients who, from age or other reason, are unfitted to stand the strain of a severe surgical ordeal. For these the choice lies between colostomy only and perineal excision as a palliative measure. Should the latter be chosen the most complete perineal excision should be carried out in order to

insure that the tissues of the lateral and downward zones of spread are effectively removed. If the latter plan be adopted the possible recurrence will be located in the tissues of the upward zone of spread above the level of the true pelvis and the patient will, in all probability, escape the misery of involvement of the sacral plexus by the growth. For all suitable cases, however, the radical operation should be performed, and preference should not be given to less radical methods purely because they are attended by a lower operative mortality rate. It should be borne in mind that, when dealing surgically with cancer, the utility of an operation should be measured, not by its operative mortality, but by the degree of immunity from recurrence which that particular operation confers.

#### THE ABDOMINOPERINEAL OPERATION

This is the radical operation for cancer and aims at removal, as completely as possible, of the tissues comprising the three zones of spread. It may be carried out in one stage, namely the one-stage abdominoperineal (the author's) operation, or it may be done in two stages with an interval of ten days or a fortnight between them, namely the two-stage abdominoperineal operation (Coffey's operation).

There appears to be a doubt in the minds of some as to what exactly is meant by a two-stage abdominoperineal operation. I have heard it said that a preliminary colostomy followed after an interval of ten days or so by perineal excision is a two-stage abdominoperineal operation. It is in fact nothing of the sort, because the tissues of the upward zone of spread are left behind. The two-stage abdominoperineal operation is nothing more or less than the one-stage operation performed in two stages with an interval of ten days or so between them.

The first stage ends with the reconstruction of the pelvic floor and the establishment of a terminal colostomy. The isolated portion of the pelvic colon together with the part of the rectum which has been

freed, anteriorly as far as the upper part of the prostate or halfway down the vagina as the case may be, laterally down to the upper surfaces of the levatores ani, and posteriorly down to the sacrococcygeal articulation, is left in situ below the new peritoneal floor of the pelvis. The isolated bowel, having been deprived of the greater part of its blood supply from ligation of the inferior mesenteric artery, necroses and, at the expiration of the interval between the stages, is in an advanced state of decomposition, so that in order to prevent absorption of toxic material a suprapubic gauze-wick drain is provided. Coffey maintained that the mortality of the operation in his hands was considerably reduced by his two-stage method and that by this method the radical abdominoperineal operation has been brought within the compass of the surgeon of average ability.

As the result of my observations upon the paths by which the spread of cancer takes place from the rectum and in consequence of the failure of the most complete operation carried out from the perineum along to prevent recurrence, I planned the radical abdominoperineal operation so as to embrace the tissues of the zone of upward spread in addition to those of the lateral and downward zones.

By this means the whole of the pelvic colon (with the exception of the portion to be utilized for the colostomy), together with the whole of the rectum encased in its sheath of fascia propria; the whole of the pelvic mesocolon; the peritoneum lining the floor as well as the walls of the true pelvis; the whole of the levator ani and coccygeus muscles; the external sphincter muscle; as much as possible of the ischio-rectal fat and a wide area of perianal skin, are removed.

Although the operation is comprehensive in its aim, it should not be reserved for advanced cases only. It should be the procedure of choice for early cases; in fact the earlier the better because then we may hope to circumvent the invisible spread of the disease. Should it be reserved for

advanced cases only, as advocated by some, then the invisible spread will have advanced beyond the confines of the operation field and recurrence will be inevitable.

The operation is a surgical procedure of the first magnitude and importance, and should not be undertaken unless the patient's general condition is satisfactory. In order to ensure a successful result attention should be paid to (1) preparation of the patient before the operation; (2) choice of anesthesia; and (3) details of after-treatment.

*Preparation before Operation.* It is most important that a week or ten days be devoted to preparatory treatment. A large number of patients suffering from cancer of the rectum also suffer from intestinal stasis, due in most instances to increasing obstruction to the evacuation of the contents of the colon. In consequence the contents of the colon are often exceedingly septic. Daily purgation and lavage not only empties the colon but reduces sepsis. In those cases in which the growth is situated at the rectosigmoidal junction, the lumen of the bowel may be so narrowed that it is not possible to wash the colon out satisfactorily. Under these circumstances, temporary cecostomy should be performed and the radical operation postponed for two or three weeks. The plan which I have followed for several years and which I have found to be very satisfactory is as follows:

1. If, on examination of the abdomen, there are no signs of intestinal obstruction the patient is given on the morning of admission 1 ounce of a mixture consisting of 2 drams of magnesium sulfate, 1 dram magnesium carbonate, and aqua chloroformi to make 1 ounce, followed at hourly intervals by half an ounce of the same mixture until the bowels act freely. As a rule five or six doses are required. If during this treatment there should develop signs of intestinal obstruction the mixture is discontinued,  $\frac{1}{2}$  gr. of morphine is injected hypodermically, and cecostomy is done at once.

2. On each succeeding morning until two days before the radical operation 1 ounce of the mixture is given. A colon washout of  $1\frac{1}{2}$  pints of plain water is administered every morning and evening, and 5 gr. of dimol are given twice daily as an intestinal antiseptic. The last dose of the mixture is given on the penultimate morning before the operation and the last washout on the morning before the operation, so that the intestinal canal has complete rest for twenty-four hours. Several hours of sound sleep should be ensured by means of a suitable soporific.

3. During the whole of the preoperative period the patient is kept on a generous nourishing diet until the morning of the operation. He should also be encouraged to take plenty of fluid to drink, to maintain his fluid content.

4. The following investigations should be carried out before the operation: (1) Blood examination including (a) hemoglobin, (b) blood group, (c) blood count, and (d) blood urea; (2) urine examination including (a) twenty-four-hour specimen, (b) catheter specimen, (c) urea concentration test.

*Blood Pressure Estimation.* Systolic and diastolic pressures are taken while the patient is at rest in bed. I regard it of very great importance that these pressures be accurately taken in order that cardiac energy can be determined by working out the Moots-McKesson "pressure-ratio percentage." This is one of the most valuable tests of operability and should never be omitted. If the pressure-ratio is below 25 per cent the operation will be fatal and if above 75 per cent the risk to life is increased. A cardiac energy index of 50 per cent is the best possible.

A thorough examination in regard to general condition should be made, particularly of the heart and lungs.

The patient should be kept in bed during the whole of the preparatory treatment.

*Choice of the Anesthetic.* Ether or chloroform anesthesia should never be employed as both these drugs produce a

marked fall in blood pressure. So far as my experience goes, the best results are obtained from gas and oxygen anesthesia supplemented by intrathecal percaïne (15 c.c. of 1:1,500 solution).

#### TECHNIQUE OF THE RADICAL ABDOMINOPERINEAL OPERATION

It must be borne in mind that one of the most important factors determining the success of the operation is the rapidity with which the various stages of the procedure are carried out. A definite system of working should be adopted, each step being completed in sequence. In an uncomplicated case the abdominal portion of the operation should be completed in forty-five minutes, and the perineal part in fifteen minutes.

#### THE ABDOMINAL PORTION OF THE OPERATION

*Position of the Patient.* Involving as it does an extensive and deep pelvic dissection, the most convenient and the best position for the purpose is the high Trendelenburg. It is important, therefore, to be provided with a good type of operating table. Most hospitals nowadays are equipped with these, but at some nursing homes the tables provided are incapable of giving the high position, and this adds immensely to the difficulties of the operation.

*Incision.* The best incision is a right paramedian, half an inch from the middle line, extending from the crest of the pubes to a point an inch or more above the umbilicus. The sheath of the right rectus muscle is incised throughout the extent of the skin incision and the muscle displaced outwards. All bleeding points having been secured, the peritoneum is opened in the middle line from one end of the wound to the other. This position of the incision is greatly to be preferred to the one sometimes adopted in the left linea semilunaris, for two reasons: first, because it affords greater facilities for carrying out the pelvic dissec-

tion of the right side; and second, because it permits of the incision for the colostomy being made at some distance from the main incision, so that the latter can be adequately protected from fecal soiling during the subsequent progress of the case.

*Exposure of the Pelvic Cavity.* A self-retaining abdominal retractor having been placed in position the edges of the wound are widely retracted. Several patterns of these retractors are in use. A rapid survey of the pelvis and the rest of the abdominal cavity is now made with a view to ascertaining whether extramural spread of the disease exists or not. The pelvic mesocolon should be carefully examined for nodules or plaques of growth. The most common positions in which these are to be found are: (a) along the parietal border, in the course of the inferior mesenteric and superior hemorrhoidal vessels; (b) along the margin attached to the colon, where the paracolic lymph glands exist; and (c) in the substance of the mesentery itself, anywhere between these two lines. If even quite minute nodules are discovered in the upper part of the mesocolon, it is direct evidence that widespread extramural extension of the disease has taken place, and the case had better be deemed inoperable. Recurrence is almost certain to ensue higher up in the median chain of the lumbar glands, or in the small intestine as a result of contact.

The failure to find evidence of the visible spread in these situations does not necessarily mean that there is an absence of extramural extension, because such spread may exist in a microscopic state. Even in such a contingency, a wide removal of the mesocolon may succeed in circumventing it. If visible spread exists, however, the widest possible removal may not get beyond the area of upward microscopic extension.

At this stage opportunity may be taken to ascertain the condition of the liver. In my experience, however, there is not much to be gained from this. If there is recognizable disease in the liver there is nearly

always obvious extramural disease in the pelvis or in the peritoneum, and if the latter is still in the microscopic stage, then any existing disease in the liver is too small to be recognized, except by post-mortem examination.

The condition of the diseased part of the bowel should next be enquired into. If the growth is situated upon the anterior wall of the bowel, especial attention should be paid to possible involvement of the urinary bladder in the male, or the posterior wall of the vagina in the female. In either of these circumstances the case is in my opinion inoperable. If the bladder is involved it is not possible to remove the growth completely; and if the vagina is implicated the additional operation of removal of the uterus and posterior wall of the vagina entails too great a strain upon the patient's endurance.

Lastly, the peritoneum lining the rectovesical pouch should be carefully examined for plaques. Very often they are not visible, but can readily be palpated. The existence of plaques and metastases, unless situated near the periphery of the operative field, does not contraindicate an attempt at the radical operation so long as the peritoneum covering them has not been penetrated. If only a small plaque exists, but its peritoneal covering has been penetrated so that the growth is exposed, the outlook is extremely bad because general peritoneal carcinomatosis will probably ensue at an early date.

In the absence of contraindications the operation is performed as follows:

First of all the pelvic cavity is cleared of small intestine. In nearly all cases there is pronounced enteroptosis, the majority of patients being at or beyond middle life. If the patient is taking the anesthetic comfortably, and especially when the abdominal muscles are completely relaxed by spinal anesthesia, the coils of small intestine usually drop out of sight into the upper abdomen; but in some instances this does not happen, and the operator is constantly embarrassed by loops of small intestine being forced down into the pelvis

during deep respiratory movements. Under these circumstances I do not hesitate to pull the small intestine out through the wound and cover it with a warm moist towel. I have resorted to this plan on several occasions, and I can confidently say that I have never seen any harm result therefrom, either from the intestine losing temperature or becoming temporarily congested as a result of its dependent position.

#### THE PELVIC PORTION OF THE OPERATION

*First Stage.* The pelvic colon is drawn through the wound and the position of its vessels noted. Occasionally there is some difficulty in doing this because the bowel is adherent to the floor or lateral wall of the pelvis. Except when the colon is the seat of diverticulosis the adhesions are not inflammatory in character but are due to altered peritoneal attachments consequent upon coloptosis. When such adhesions are found they should be freely divided on the outer side of the pelvic mesocolon so as to mobilize the adherent part of the bowel, and thus permit of its being delivered outside the abdomen.

In my earlier cases I was in the habit of dividing the pelvic colon at the seat of election as the first step of the operation. For this purpose a point in the pelvic colon was selected between the areas of distribution of the first and second sigmoidal branches of the inferior mesenteric artery. To this point an intestinal crushing clamp was applied and left on for two or three minutes. For some time past, however, I have left the division of the bowel to the end of the pelvic part of the operation and ligature the inferior mesenteric artery, at the seat of election, before doing anything else. The ligature is applied between the first and second sigmoidal branches.

When the pelvic mesocolon contains little fat the position of these vessels can be seen clearly, and there is no difficulty in applying the ligature at the correct spot; but in obese subjects the vessels cannot be seen. Under these circumstances it is advisable to place the ligature on the

inferior mesenteric artery at the level of the bifurcation of the abdominal aorta, as that point is half an inch below the origin of the first sigmoidal branch, and well above the origin of the second branch.

It is never necessary to expose the vessels by dissection, as, by so doing, somewhat free bleeding may ensue from branches of the sigmoidal veins which obscures the view and embarrasses the operator. The simplest way is to transfix the pelvic mesocolon by passing an aneurysm needle behind the inferior mesenteric vessels at the level of the bifurcation of the aorta, and then to ligature the mesocolon en masse. In applying this ligature the position of the left ureter must be borne in mind.

At the level of the bifurcation of the aorta the ureter is from  $\frac{3}{4}$  inch to 1 inch to the left of the inferior mesenteric artery, but at the level of the promontory of the sacrum they are close together, so that if the mesocolon is transfixed too low down, the ureter is in danger of being included.

Ligature of the inferior mesenteric artery, as the first step in the operation, ensures a practically bloodless field during the subsequent steps of the pelvic portion of it and is, therefore, essential. This having been done, a second ligature is placed on the vessels about an inch below the first in order to control venous bleeding from the distal part of the mesocolon when it is divided.

*Second Stage.* The pelvic mesocolon is divided completely immediately below the first ligature, and then the peritoneum, on either side of the line of origin of the mesocolon, is incised downwards as far as the promontory of the sacrum. When this is being done on the left side, the position of the left ureter should be carefully ascertained lest it be divided or otherwise injured. As soon as the peritoneum has been divided on both sides as far as the promontory, the cellular space, between the anterior surface of the sacrum and the terminal part of the pelvic mesocolon, comes into view.



By thrusting the fingers of the left hand into this space the terminal portion of the pelvic colon and the rectum can be stripped readily from the anterior surface of the sacrum as far as the sacrococcygeal articulation. At the latter point the fascia propria of the rectum is closely adherent to the periosteum of the lower border of the sacrum and cannot be stripped away from it, thus indicating that the level of the articulation has been reached.

Occasionally one or two dense bands of connective tissue extend from the fascia propria to the sacrum. These should be divided with scissors rather than torn from their sacral attachments, lest by so doing a presacral vein be lacerated and give rise to troublesome bleeding. The left hand is now introduced into the presacral space thus opened up and the rectum is pressed forward and upward in order to raise and render prominent the peritoneum lining the floor and the lateral walls of the pelvis. The pelvic peritoneum thus raised is divided forward on either side parallel to the brim of the true pelvis as far as the base of the bladder, care being taken not to injure the ureters which often adhere closely to the peritoneum. These incisions in the peritoneum, along the brim of the true pelvis, are continued until they meet anteriorly behind the base of the bladder in the male, or the upper part of the vagina of the female.

*Third Stage.* The separation of the anterior wall of the rectum from its connections is next preceeded with. In the male, a well-marked stratum of loose areolar connective tissue exists between the fascia propria of the rectum and the layer of rectovesical fascia which binds the vesiculae seminales to the base of the bladder. When this line of cleavage is found, the separation of the rectum from the vesiculae seminales and the base of the bladder is easily affected, but unless care be exercised the space containing the vesiculae may be opened up, and then the dissection becomes extremely difficult, so that the vesiculae or the vasa deferentia

may be injured. It is important that the separation of the rectum anteriorly should extend as far as the upper border of the prostate gland.

*Fourth Stage.* As soon as the rectum has been freed from its connections both anteriorly and posteriorly down to the points indicated above, the lateral attachments of the rectum can be readily made out. These consist, on either side, of a broad band of dense connective tissue, varying in depth from 2 to 3 inches, which passes forward and outward from the lateral walls of the rectum toward the base of the bladder at the point where the ureters terminate. These bands, the lateral ligaments of the rectum, must be completely divided down to the upper surfaces of the levator ani muscles. The middle hemorrhoidal artery, which passes in the substance of the ligament to its distribution, is always divided but is seldom of sufficient size to need a ligature.

*Fifth Stage.* The rectum having thus been freed from its connections, anteriorly as far as the upper border of the prostate, posteriorly down to the level of the sacrococcygeal articulation, and laterally to the upper surfaces of the levator ani muscles, the pelvic colon is crushed at the seat of election, that is, at a point situated about 3 inches from the termination of the descending colon. A broad-bladed crushing clamp (author's pattern) is applied to the colon at the point indicated, and then the crushed area is ligatured in two places. The bowel is divided between the ligatures and the ends of the bowel protected by tying a piece of green protective over them. In my earlier cases I invaginated the ends by means of a purse-string suture, but have abandoned the practice in favor of the more speedy method of covering them with green protective.

*Sixth Stage.* The occluded end of the distal part of the pelvic colon is next pushed down into the presacral space until it rests at the level of the sacrococcygeal articulation, where it can be

easily reached when the perineal portion of the operation is being performed. The remainder of the distal part of the pelvic colon is then crowded down into the cavity of the pelvis and preparations are made for reestablishing the floor of the pelvis by peritoneum.

Owing to the free removal of the peritoneum lining the floor and the lateral walls of the pelvic cavity, a large gap remains. On no account should the pelvic mesocolon be left in situ with a view to facilitating the closure of the gap, because this structure is largely concerned with the extramural spread of the disease, and is, therefore, to be regarded as highly dangerous tissue.

I cannot emphasize too strongly the necessity of completely removing this structure in every case, together with a wide strip of the adjacent peritoneum, if immunity from recurrence is to be hoped for. The gap cannot be closed by dissecting up the peritoneum from the lateral walls of the pelvis. However much the peritoneum is mobilized at the sides of the gap, the edges can only be approximated posteriorly in front of the promontory of the sacrum and sutured to the stump of the pelvic mesocolon.

The large pear-shaped gap remaining after this has been done can be readily filled in, however, by dissecting up the peritoneum from the base of the bladder in the male, stretching it back across the gap and suturing it there, (or by dissecting up the innermost layers of the broad ligaments in the female and utilizing them to fill up the space.

It is of the utmost importance that the suture line in the new peritoneal floor should be intact. Therefore, when the peritoneum is thin and likely to tear an omental graft should be used to reinforce it.

It will be observed that the new peritoneal floor of the pelvis differs from the normal in that it is situated at a much higher level, that is, at the brim of the true pelvis. Consequently, during the

healing process, a new rectovesical pouch is formed, partly by stretching of the peritoneal floor and partly by dragging down the peritoneum of the iliac fossae. On the right side, the terminal ileum is adherent to the peritoneum of the iliac fossa, and therefore a drag upon the peritoneum in this situation may produce a pronounced ileal kink.

Accordingly, as soon as the new peritoneal floor has been completed, any tendency to kinking of the ileum at the point where it enters the cecum should be corrected.

*Seventh Stage.* The proximal end of the pelvic colon is now utilized for establishing a colostomy. The best position for this is at a point situated  $1\frac{1}{2}$  inches internally to the left anterior superior spine of the ilium, along a line extending from that bony prominence to the umbilicus. A short incision,  $1\frac{1}{2}$  inches long, is made, the center of which intersects the above-mentioned line at right angles. This incision extends through the skin and subcutaneous tissues only. The aponeurosis of the external oblique muscle is now divided to the extent of 1 inch, and then the muscular fibers of the internal oblique and transversalis muscles are separated in the direction of their fibers by blunt dissection.

An opening just large enough to admit the index finger is made through the transversalis fascia and the peritoneum. Through this small opening the stump of the proximal end of the pelvic colon is drawn, and fixed in position at the upper and lower angles of the wound by means of silkworm gut.

I do not think there is any advantage in bringing the bowel out through the fibers of the left rectus abdominis, as is sometimes advocated in the performance of colostomy. The chief point to be borne in mind is to make the opening just large enough to allow the stump of the bowel to be drawn through it, and no larger, lest herniation of small intestine between the bowel and the edge of the wound should occur.

The abdomen is now closed and a temporary dressing applied. The Trendelenburg position is dispensed with, and the patient is placed in the right dorsal and semiprone posture in order that the perineal portion of the operation may be carried out.

#### THE PERINEAL PORTION OF THE OPERATION

*Incision.* The anus having been closed by means of a purse-string suture, a transverse incision about 4 inches in length is made at the level of the sacro-coccygeal articulation. From the center of this a longitudinal cut is made in the internatal furrow, and carried down to a point 1 inch from the posterior margin of the anus. From the inferior extremity of this, incisions are carried to the right and to the left of the anus in the shape of a horseshoe, and the anterior extremities of these are joined by a transverse cut. It is important that the arms of the horseshoe should embrace as wide an area of perianal skin as possible, because the skin in this region is especially prone to develop recurrent growth. The gluteal skin-flaps are then reflected and retracted out of the way, thus laying bare the coccyx.

*Removal of the Coccyx.* The sacro-coccygeal joint is opened and the coccyx dissected out. The incisions surrounding the anus are then deepened so as to include as much as possible of the ischio-rectal fat. It is never necessary to remove a piece of the sacrum, as ample room is provided by removal of the coccyx alone. In fact, sufficient room for the completion of the operation can be obtained without even removing the coccyx. However, I think it best to remove it, because the coccygeus muscles must be removed and the bone would then be left without any lateral attachments.

*Exposure of the Presacral Cavity Containing the Isolated Bowel.* A small transverse incision is made into the dense connective tissue immediately below the

sacrum, where the attachment of the fascia propria recti can readily be detached from the ventral aspect of the lowermost piece of the sacrum. The index finger is then thrust into this, and, supposing that the separation of the rectum from the front of the sacrum has been carried down to the level advocated above, it readily passes into the space containing the isolated bowel. A transverse incision is then made through the coccygeus muscle on either side, extending-outward as far as the great sacrosclatic ligaments. Through the ample opening thus made the isolated bowel is drawn down to its full extent.

When the separation of the anterior connections of the rectum have been carried down to the prostate during the abdominal part of the operation, the base of the bladder and the vesiculæ seminales, with the vasa deferentia and the upper part of the prostate, come into view. In the female the uterus and the upper half of the posterior vaginal wall can be plainly seen.

*Division of the Levatores Ani Muscles and Severance of the Remaining Connections of the Rectum.* By making traction upon the bowel with the left hand the levatores ani are put upon the stretch. If they do not come into view it is because the lateral ligaments of the rectum have not been completely divided from above. In that case considerable difficulty may be experienced in delivering the loosened bowel through the perineal wound, and until the lateral ligaments have been completely severed the levatores cannot be divided. The levatores are now divided at their origin from the lateral wall of the pelvis, the puboprostatic fibers being detached from the prostate.

All that now remains to be done is to dissect away the anterior wall of the anal canal from the tissues forming the central point of the perineum, great care being taken not to wound the membranous portion of the urethra in so doing.

*Completion of the Operation.* After the removal of the rectum and isolated portion

of the pelvic colon, usually about 16 inches in length, a large cavity is left. This cavity is surrounded by bony structures behind and at the sides, and it is absurd to suppose that it can be sewn up so as to obtain healing by primary intention. The cavity must heal gradually by granulation, portions only of the skin incision being brought together by sutures.

I always pack the cavity with long strips of gauze, to afford support to the new pelvic floor formed only by peritoneum. It is not advisable to allow the gauze to be in direct contact with the walls of the cavity, because it becomes firmly adherent to them and gives considerable trouble and pain to the patient when it is removed.

In one of my earlier cases the peritoneum of the pelvic floor was torn when the gauze was removed, and a coil of small intestine became herniated through the opening. I always use a sheet of green protective, 2 feet square, for lining the cavity, and then pack the gauze into it, the subsequent removal of the gauze thus being rendered easy and painless. Dressings and bandages are then adjusted, and the patient is turned upon his back so that the abdominal wounds may also be dressed. Before the patient leaves the table the ligatures closing the stump of the proximal end of the pelvic colon are removed, and the open end of the bowel is covered with green protective and a pad of gauze.

*Postoperative Treatment.* Immediately after the operation has been completed a blood transfusion (500 c.c.) should be given, preferably by the drip method. There is no doubt that this is the best means of combating postoperative shock. Immediately afterward, a solution of

dextrose saline is given, at the rate of 30 drops to the minute, during the following forty-eight hours, for the purpose of preventing dehydration.

As soon as the patient returns from the theater the foot of the bed is raised and an electric radiant-heat cradle is fitted over him, the temperature being carefully regulated.

No fluid by mouth is allowed during the first forty-eight hours in order to lessen the risk of acute gastric dilatation. Careful watch for the onset of this complication should always be kept and as soon as the subxyphoid depression becomes effaced the stomach should be emptied by passing the stomach tube.

The perineal wound is dressed for the first time seventy-two hours after the operation. After the gauze packing has been removed the cavity is irrigated with (1) hydrogen peroxide (10 vols.) 1 pint, followed by (2) perchloride of mercury (1:500) 1 pint, followed by (3) 2 pints of normal saline solution. Irrigation with these solutions is carried out twice daily during the first week, after which period a solution of iodine or of dettol (2 drams to the pint) is substituted.

On the morning of the fifth day an enema is administered by the colostomy and on the following day a saline purgative is given. The colostomy washout is repeated daily.

At the end of a week the excess of bowel forming the colostomy is removed. Digital dilatation of the colostomy stoma is carried out daily until the tendency to contract, during the healing process, has ceased. The patient is allowed to get up for the first time on the eighteenth day for twenty to thirty minutes.



# THE SURGICAL TREATMENT OF CANCER OF THE RECTUM

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THERE are fashions in surgical procedures just as there are in the design of women's clothes. For a time some particular operation becomes the standard practice in all the important clinics so that it is performed almost to the exclusion of any other method, and then in the course of a few years we find it has been entirely replaced by some other procedure. Often there are good reasons for the change-over, but I am inclined to think that this is not always the case and that some particular operative procedure is liable to be adopted just because it is the fashion and not as the result of a careful study of the end results.

I have been in practice long enough to have seen many such changes; some have been definitely advantageous, but I am not so sure of others. As an example we may take the operation for gallstones. Some years ago the standard practice was to drain the gall-bladder, cholecystotomy, while today the operation that is almost exclusively performed is removal of the gall-bladder, cholecystectomy. Now the end results of cholecystotomy were often very satisfactory and I have a suspicion that today many patients with gallstones would be better if they had their gall-bladders drained rather than removed.

Then again, gastroenterostomy was a most satisfactory operation, which has been entirely replaced by gastrectomy. There also I am not sure that the change is entirely beneficial. We are beginning to see cases of anemia following gastrectomy.

We come back to the fact that the wisest course is to fit the operation to the patient and not the patient to the operation. Some cases that are now treated by cholecystectomy would do better if their gall-bladders were drained, and some patients now treated by gastrectomy would do better

if treated by gastroenterostomy. We should not allow ourselves to become stereotyped in thinking that there is only one operation for the treatment of all cases of a particular disease. We should study the particular case and perform that operation which in our judgment will be the safest and will be most likely to restore the patient to perfect health, and should not allow ourselves to be prejudiced into performing some particular operation just because it happens to be the fashionable one at the time.

This applies also to operations for cancer of the rectum. We have in the last twenty-five years seen many changes in the standard operations performed for this disease. There is my two-stage perineal excision; there is the Miles technique for performing a one-stage abdominoperineal excision; there is the modification of perineo-abdominal excision in one or two stages; and lately various methods, mostly revivals of old methods, for local excision and restoration of the rectum.

I propose here to discuss the pros and cons of these operations, so as to assist the young surgeon in coming to a decision when he is called upon to deal with a case of cancer of the rectum. I would like again to stress the fact that there is no one method which is applicable to all cases and that no surgeon should aim at one standard practice. While it may pile up his own statistics it will be at the expense of his patients and his own results will not be so good as those of the surgeon who uses the technique most suitable for the individual case.

Although the method of excising the rectum by the perineal route, which goes by my name, has now become the standard practice for suitable cases of cancer of the rectum, I have never suggested that it is the only method of removing the rectum,

or that it should be practiced to the exclusion of other methods. I have, it is true, used the perineal two-stage method of excising the rectum in most of the cases that I have treated, but when another method seemed for some reason or another better suited to the particular case I have always adopted that method which seemed to me to give the patient the best chance.

Let me start by saying that the ideal operation for removing the rectum for cancer has not yet been devised, and it is possible that it never will be as there are so many conflicting difficulties.

It is obvious that no method can be ideal which leaves the patient with a permanent colostomy. Numerous attempts have been made, both by myself and others, to find a technique that will allow of the removal of the growth and yet leave the patient with a normally functioning bowel. Many of these methods have been quite successful in that the restoration of the rectum has been achieved, and I have several patients alive and well with a normally functioning rectum from whom I removed a rectal carcinoma many years ago. But the method has been discarded except in a very few cases of early growths of a low malignancy (Grade 1, Broder's) owing to the frequency of recurrence in cases so treated. Were it possible to be certain previous to operation that the tumor has not spread beyond the rectal wall, this method would be justifiable, but at present there is no means of selecting suitable cases with any certainty. In other words, much earlier and more accurate diagnosis is necessary before local resection of rectal growths can be successfully practiced.

When the surgeon is called upon to treat a case of carcinoma of the rectum there are several factors that he has to take into consideration before deciding upon the particular method which will give the best result for his patient:

1. He must be as sure as possible that his operation will entirely eradicate the disease and, as far as may be, do away with the chance of recurrence. This is the first

consideration because without it the operation is doomed to failure and might as well not be done at all.

2. The operation must be reasonably safe and, so far as other considerations make this possible, give the patient the maximum chance of survival.

3. When the patient is old, feeble, or the subject of some other disease or disability, if an operation is decided on one must be chosen which will give a reasonable chance of survival. The more drastic procedures are ruled out.

4. In a young person (50 or under) that operation should be chosen which will give the best chance of completely eradicating the disease, since the younger the patient the greater is the risk that the tumor has already spread to the lymphatics and other tissues.

The surgeon should not choose any particular operative procedure just because other people advocate it or because he has seen it done in famous clinics or because it seems the easiest method. He should study the actual facts as regards operative mortality and especially recurrence rates, which are now available about all the well established operations for rectal cancer. He may then choose that one which seems to be most suitable for the particular case he has to treat.

Let us consider some of the advantages and disadvantages of the various standard operations as now performed for rectal cancer.

#### THE PERINEAL EXCISION IN TWO STAGES

This method is suitable in any case where the tumor is confined to the rectum proper and where the examining finger can reach to or above its upper limits. The first stage consists in exploring the abdominal cavity to make sure that there is no involvement of the liver and that the growth has not spread into the abdominal glands or involved the peritoneum, and in establishing the colostomy opening.

Since the colostomy is to be permanent, some care should be taken in making it as

satisfactory as possible. There should be a complete bridge of skin and abdominal wall between the two openings of the colon, as this will prevent any possibility of fecal matter finding its way into the lower blind opening and will also militate against the subsequent formation of a ventral hernia at the site of the colostomy.

From a week to a fortnight should be allowed to elapse between the first stage and the second for the removal of the rectum. This will enable the abdominal wound to heal and the bowel between the colostomy and the anus to be thoroughly washed out and cleansed. It will also give time to get the patient's bowels properly regulated: a very important point since most patients with a growth in the rectum are suffering from some degree of intestinal stasis.

At the second stage the entire rectum and anus are removed by the perineal route. A description of the actual technique will not be given here as it can be found in most of the standard textbooks. (A full description appeared recently in *Surgery, Gynecology and Obstetrics*, Nov., 1938.) This second stage can be very rapidly performed unless some special difficulty presents itself, the time varying from twenty-five minutes in an ordinary case to fifty minutes in a very difficult one, in the hands of a skilled surgeon.

The mortality is the lowest of any method for excising the rectum. The lowest operative death rate in the author's hands was 4 per cent for 150 cases which compares very favorably with an operation upon patients of equivalent average age.

A low operative mortality is of little value unless it is accompanied by a low rate of recurrence as shown by a careful follow-up extending over many years. Over 500 cases treated by this operation have now been studied and show a five-year cure rate of over 55 per cent. This is at least as good as for any other of the standard operations for cancer of the rectum, and has established this method as the best so far for those cases to which it is suited.

There are very many cases of cancer of the rectum where the patient is a bad surgical risk either because of age, infirmity, or accompanying disease, and in such cases if there is a reasonable chance of eradicating the growth completely by this method it should be preferred. It is often possible by this method to cure a patient of cancer, who would have little chance of survival if treated by a combined route.

The disadvantages of this operation are that it is not suitable where the growth is situated high up or is at the rectosigmoid junction, or where the tumor is very large and is filling up a large part of the posterior pelvis space. It is also not at all an easy operation to perform, though with practice it is not unreasonably difficult.

It can quite easily be performed in one stage, the colostomy being done first and the abdomen explored, then the patient is turned over and the rectum removed. In elderly subjects or bad risks, it is, however, safer to perform it in two stages.

#### THE COMBINED ROUTE

It was the practice until the last few years to make use of the combined abdominoperineal route in all cases where the tumor was situated too high up in the rectum for removal by the perineal route, and in cases where there was reason to doubt the possibility of completely eradicating the disease by the latter method. Today the abdominoperineal route is seldom, if ever, used, at any rate in St. Mark's Hospital, as it has given place to the perineo-abdominal route.

The advantages of perineo-abdominal approach are that the operation is much more easily performed and is quite appreciably quicker. The closure of the peritoneal floor from the abdomen after the complete removal of the bowel and tumor is quite a simple procedure, whereas in the abdomino-perineal operation where the peritoneum has to be stitched up over a mass of bowel and tumor pushed down into the posterior pelvis, it is often quite difficult.

The whole operation has been completed in fifty-six minutes, or, with two surgeons working at the same time, in forty minutes. I feel sure that the perineo-abdominal operation will entirely replace the older abdominoperineal method.

The operation may be performed either as a one-stage or two-stage operation. If performed in one stage, the abdomen is first opened by a midline incision and explored, then the wound is temporarily closed and covered over. The patient is turned over into the left semi-prone position. The operator now dissects the rectum free by the same procedure as if he were going to perform a perineal excision. When the peritoneum has been opened from below and the lateral fascial attachments have been divided, a glove or rubber bag is drawn over the rectum and it is pushed up into the depths of the wound. A piece of rubber sheeting is then placed in the wound and inside this a strip of gauze packing is placed, the ends of the rubber and packing being brought out as a drain and the skin closed tightly round. The patient is then turned on the back again, the abdominal wound reopened, and the rectum pulled out of the pelvis. The peritoneum is divided on each side of the mesocolon and the main vessels ligatured. The gap in the peritoneal floor is now closed with stitches: the bowel is brought out through a separate wound in the abdominal wall on the left side, or through the upper part of the main wound, and the abdominal wound is closed in the usual way. Last of all the colon is divided an inch away from the skin between clamps. This completes the operation.

The objections to this method are that it necessitates turning the patient over into a new position twice during the operation. This not only wastes time—at least fifteen minutes—but it causes a certain degree of shock and disturbance of the circulation.

Recently attempts have been made to get over this difficulty by putting the patient before operation into a special—Trendelenburg—lithotomy position by means of special thigh pieces attached to

the table. This enables the surgeon to perform the whole operation without disturbance of the patient or towels. A full description of the technique was given by Mr. O. V. Lloyd-Davies in the *Lancet* (July 8, 1939). This position saves a great deal of time and with two surgeons working at the same time the whole operation has been completed in forty minutes.

A one-stage perineo-abdominal operation should never, or at least very rarely, be performed without first making an abdominal incision to ascertain whether there are metastatic deposits in the liver or elsewhere. It is rather tempting to perform the operation without this exploratory incision, but if this is done there is a grave danger that the patient may have been subjected to a serious operation which has no hope of being curative.

This form of combined perineo-abdominal resection, which was first described by Mr. W. B. Gabriel, has, it seems to me, great advantages over the abdominoperineal method, and the disadvantage of having to move the patient twice can be entirely done away with if the new Trendelenburg-lithotomy position is made use of. The operation is easier, quicker and safer. It also has the advantage that if during the performance of a perineal excision the surgeon finds that the operation will not give him a sufficiently wide removal of the tumor, or that he is in difficulties owing to the tumor being larger and more inaccessible than he expected, he can turn it into a combined operation by finishing in the abdomen.

#### THE ADVANTAGES OF A TWO-STAGE OPERATION

I have always felt that in many cases requiring removal of the rectum it is advisable to do a two-stage rather than a one-stage operation. Many of the patients are partly obstructed and are suffering from toxemia owing to the fact that the growth is causing serious narrowing of the bowel lumen, or because it is preventing by



its presence satisfactory evacuations. It is often not possible to clear the bowel out satisfactorily, and if this is so, and it is not infrequently the case, the patient is not in good condition to stand up to such a serious operation as complete removal of the rectum. One has only to observe the very improvement which takes place in such patients after a preliminary colostomy to be convinced of the advantages of performing the operation in two stages.

Surgeons as a whole have been so impressed with the advantage of doing a decompressing operation first (if I may use the term) especially in the case of old or feeble subjects, that a preliminary colostomy, either temporary or permanent, is now the usual practice for all operations for carcinoma of the large bowel.

For this reason it has become the usual practice to perform perineal excision of the rectum in two stages. If a two-stage operation is advantageous in performing perineal excision then it should be even more advantageous when performing the more severe combined operation.

There are, however, certain difficulties about doing the combined operation in two stages, which have so far not been entirely got over. The objection that a colostomy opening on the abdominal wall renders it difficult to keep the laparotomy wound free from infection is not serious, as the wound can be completely protected by rubber sheeting stuck to the skin with mastic and by towels clipped to the skin edges. With proper technique the surgeon should have no anxiety about the infection of the laparotomy wound owing to the presence in the neighborhood of the colostomy opening.

The real objection is that so far surgeons have not discovered a satisfactory means of dealing with the section of bowel between the colostomy opening and the rectum. The obvious method of dividing the colon, bringing the upper end out as a terminal colostomy and sewing over the lower end and dropping it into the pelvis, has proved

unsatisfactory. No matter how carefully this is done, it is invariably discovered when the rectum is removed that this blind end of the colon has formed tiresome adhesions to some contiguous structure with resultant waste of time in freeing the adhesions and often serious risk of infecting the wound.

An alternative method suggested by Lahey of leaving the lower end of the colon open to the surface and dissecting it out before again opening the abdomen has also not proved satisfactory, as adhesions form around the sides of the blind bowel inside the abdomen.

My own practice has been to perform the original colostomy in continuity, which allows the rectum to be thoroughly washed out from above, and at the end of the second stage to divide the colon as close to the inside of the abdominal wall as possible. This method works fairly satisfactorily, but although I always cover over the turned in end of the colon with omentum or fat, I have had trouble in some cases from sepsis in the blind stump. The ideal method would be to dissect out the stump of blind colon at the end of the operation instead of leaving it in place, but this involves the expenditure of valuable time and the risk of infection from the colostomy opening.

It must be admitted that so far a satisfactory solution of this little problem still awaits discovery, and in the meantime most surgeons, unless the condition of the patient obliges them to do a preliminary decompressing operation, prefer to perform the whole operation in one stage.

There is still plenty of room for improvement in the surgical treatment of cancer of the rectum, but it must always be remembered that the patients are as a rule elderly and that no operation which is accompanied by a high mortality rate is justifiable, since well tried methods with a reasonably low mortality rate can be used. In a long series of cases these have proved satisfactory from the point of view of five years' freedom from recurrence.

# OPERABILITY AND TYPES OF SURGERY IN CANCER OF THE RECTUM

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OPERABILITY statistics on carcinoma of the rectum are at great variance, being quoted in the literature at from 25 to 75 per cent but, unfortunately, when figures are quoted, the manner in which they are arrived at is not stated and the reader is confused. Many of the statistics are presented by able surgeons of equal capabilities and the wide difference can only be explained by the fact that figures are arrived at by entirely different methods of analyzing groups of cases. For instance, the patient is advised to have an operation but does not return. Where should that case be classified if examination revealed it to be favorable for operation? Another instance is where the surgeon is called in consultation when the patient is in extremis. Where should this be included in the statistical study? It seems to me that a simple method of computing our statistics could be used so that series of cases could be compared on an equal basis.

I thought it might be of interest to take a series of 100 consecutive cases as they came in for examination and follow them through to find out exactly what happened in each individual case. In the table below are listed 100 consecutive cases as they appeared for examination with primary, untreated carcinoma of the rectum.

TABLE 1

A. Patients examined.	100
B. Radical operation advised, did not return	10
Balance.....	90
C. Operation not advised, too far advanced	11
Palliative procedure advised	9
	20
D. Operated upon for cure	70
E. Inoperable at exploration	
Liver involved . . .	10
Local fixation . . .	3
	13
F. Operation completed	57

It can be seen from a glance at this table that operability percentage can be figured in many different ways. There were fifty-seven completed operations and the percentage can be figured on a basis of 100, or ninety, or seventy, or, as a matter of fact, from a standpoint of local extension, on the figure of sixty. These operability percentages, therefore, could vary from 57 per cent to 97 per cent. It is also seen from the table that ten patients who were considered clinically operable did not return for treatment for various reasons, namely, distance from home, objection to colostomy, or desiring another hospital or surgeon. I myself think that the operability percentage should be computed on the basis of ninety.

As is shown in Group c there were twenty cases which were considered inoperable. Here again one could roughly estimate that the operability was 80 per cent, but it is not a true picture of the series of cases. Therefore, there remained seventy cases which were considered clinically operable and which were sent to the hospital, radical operation being the advised treatment. However, at operation it was found that the liver was involved in ten cases, and it was impossible to remove the growth in three cases on account of local fixation. Therefore, out of the seventy cases, there were fifty-seven completed operations. Here again, one may say that his operability was fifty-seven out of seventy cases, or 81.4 per cent. This also does not give a true picture because it eliminates twenty cases which were clinically inoperable due to various reasons.

It is quite apparent, then, why operability figures vary. For purposes of comparison, therefore, operability figures should be

reported both in relation to the total number of cases seen and those cases in which operation was advised, and also in relation to the number of cases which had exploratory operations.

In this group of 100 consecutive cases, the types of operations performed in fifty-seven are as follows:

	Cases
Combined abdominoperineal resection in one stage.....	54
Colostomy with posterior resection...	1
Colostomy with segmental resection..	1
Electrocoagulation.....	1
Mortality: 4—Based on 56 major procedures, equals 7.2 per cent	

A variety of procedures and different techniques for the same operation have been handed down over the years. In fact, there are far too many to go into detail, but in the final analysis, the controversy lay over the selection of a perineal anus or an abdominal colostomy. Both have their advocates and the procedure of choice is generally based on previous training and experience. Eventually, if we can secure an accurately controlled group of cases for comparison, the procedure which will win out will be the one that offers the highest rate of curability.

My earliest recollection of the various types of operations is of the simple posterior excision without exploration or colostomy. The operability was low, the mortality rate high, and curability rate not good. I think that the only occasion for employing this type of operation is in elderly people with anorectal cancer—a very small group of cases. Here the spread is to the inguinal glands and exploration may be dispensed with if it adds materially to the risk.

In this country, colostomy and posterior resection in two stages enjoyed considerable popularity for many years. While I have not had a great deal of experience with it, those who have had are abandoning it as a routine procedure because experience has again shown that the rate of curability may be improved upon by more radical measures. This fact was quite apparent to

me years ago; therefore, I could not become enthusiastic about it.

In order to preserve the sphincteric apparatus, the Kraske approach and segmental resection with anastomosis posteriorly has been sporadically used, but it is mentioned only to be condemned as any type of operation for eradication of cancer. In instances where it has been successful, the tumor was limited to the mucosa and in such cases I believe it could have been cured by much simpler means, namely, electrocoagulation or implantation of radium seeds as we have demonstrated in a small group of cases. Here again, however, of the total number seen, the percentage limited to the mucosa is very small. It is to be hoped that we would see all of these cases when they were limited to the mucosa where simpler procedures would give even a higher rate of curability than we are now able to obtain by radical procedures.

I am still of the conviction that the abdominoperineal resection (Miles operation) offers the best chance of cure, or a longer period of immunity from recurrence. Personally, I am unable to reach the bifurcation of the aorta by any posterior approach and, when doing the abdominoperineal operation, this is usually the starting point in the removal of all vulnerable areas of spread. In our present day knowledge of cancer it is unreasonable to assume that an operation smaller in scope will give as high a percentage of cure as the abdominoperineal resection. This operation may be done in one or two stages; however, one must use the type of operation with which he is most familiar and which the facilities at hand permit. My preference has always been the one-stage operation, the technique of which has been described previously.<sup>1</sup> The two-stage procedure is resorted to only in cases where there is an obstruction which cannot be relieved by routine medical management for a week before operation. This preoperative treatment, I am sure, is one of the greatest factors which has resulted in a low opera-

tive mortality. We must also bear in mind that when two major procedures are performed on a patient, the possibility of accidental death is doubly increased, so it is not necessarily a safer procedure. Then again, after the first stage has been done complications sometimes arise which may indefinitely postpone the completion of the second stage.

This operation has been reversed, making it a perineal-abdominal procedure, the perineal portion being done first and the abdominal part second. However, this necessitates a previous laparotomy to investigate for metastases, and this operation is therefore really an abdominoperineo-abdominal-perineal operation, the last maneuver being the packing of the posterior cavity. Bartlett and Rankin in this country and Gabriel in London have had some experience with this procedure, but to me it seems to involve more work than is necessary in order to accomplish the same thing.

*Palliative Treatment.* While I am a staunch advocate of the colostomy, there is a certain group in which I think it is not indicated. As will be seen in column C, Table I, palliative operation was not advised in eleven cases because it was

thought that it would not materially add to the comfort of the patient. The pain of obstruction must be distinguished from the pain of extension. If there is no obstruction, we are merely adding to the patient's discomfort by giving him a colostomy because it does not necessarily remove one of the greatest complications, namely, frequency and urgency of stool. The ulceration accounts for the frequent emissions of pus, mucus, and blood, and the colostomy will not prevent this. Therefore, the patient has two nuisances instead of one.

### CONCLUSIONS

It seems to me that the simple table presented in this article would be of value in reporting operability statistics. At a glance one could then compare the figures given with his own.

With regard to the type of operation, I think that the abdominoperineal resection offers the best chance of cure in any case where it can be carried out.

### REFERENCE

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# CHOICE OF OPERATIVE PROCEDURE FOR CARCINOMA OF THE RECTUM\*

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A DECIDED majority of those who are interested in the treatment of patients with carcinoma of the rectum, including surgeons, internists and radiologists, consider surgery the treatment of election in most of the cases that are operable. It is not within the scope of this presentation to discuss the relative merits of surgery and radiotherapy. Cade,<sup>1</sup> a few years ago, probably expressed the opinion of most surgeons when he stated: "At the present stage of radium therapy it must be admitted that for cancer of the rectum and colon, a correct surgical excision gives the patient as good a chance of cure as can be hoped for. As, however, a similar statement was true for cases of buccal cancer about six or eight years ago, it is not unreasonable to believe that with advancement of knowledge and with improved technique the position may be altered within the next few years." Very definite progress is being made in the field of radiotherapy as applied to cancer of the rectum; however, until remedial agents than surgery offer more favorable expectations of cure or palliation it is my opinion that resection clearly is justifiable in all cases up to and frequently including those of borderline operability. Extirpations for the latter group, however, are often formidable and require not only a certain measure of skill but considerable courage.

A case which is considered operable by one surgeon may be considered inoperable by another. The surgeon who is satisfied with an operability of 25 per cent may do posterior resection or even local excision with low mortality and a high percentage of patients who survive for three to five

years, but by so doing he abandons another 25 per cent or more of those patients whose condition might be operable in the hands of a surgeon who is bolder and does a more radical resection. Moreover, the latter will have a much larger number of five-year survivals in a given number of patients originally examined and on whom a diagnosis of carcinoma was made.

Save for the small group of patients who present themselves with acute intestinal obstruction, carcinoma of the large intestine may be considered, insofar as its surgical treatment is concerned, as a chronic disease. This is of foremost significance in that it allows time in which to institute preliminary medical measures aimed at increasing factors of safety in the extirpation of these lesions. Chronic obstruction of the large intestine deserves careful consideration because of the accompanying rapid debilitation and desiccation. Prolonged absorption of the septic contents of the colon through its damaged mucosa and that of the terminal ileum causes a lowered physiologic state which has a direct bearing on the outcome of any type of operation. Peritonitis, bronchopneumonia and other postoperative complications which result even from simple operative procedures instituted for relief of obstruction or for palliation are probably directly the result of intoxication due to obstruction.

If the obstruction is acute, which has been quite infrequent in my experience, or of the chronic type which has failed to respond adequately to the usual medical measures of decompression, drainage by cecostomy or colostomy proximal to the

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growth is urgently indicated as a preliminary step to subsequent resection. While this is now a well recognized surgical principle and is more or less the general practice, many surgeons continue to explore the abdomen at this time; relief of the immediate obstruction is the paramount consideration and manipulation of the colon under such circumstances is highly dangerous due to the likelihood of perforation or of spread of organisms which may have penetrated the distended, attenuated wall of the colon. Although I recognize the tremendous advantage of preliminary cecostomy or colostomy as an adjunct to surgery of the left half of the colon and rectum and believe that its employment is invariably demanded in the following instances: (1) acute obstruction, (2) chronic obstruction unrelieved by medical measures, and (3) resection of the rectosigmoid followed by immediate anastomosis, I do not consider such a step essential to safe surgery of the rectum when obstruction is absent or has been adequately relieved. The proof of this to me has been the practical experience with a goodly number of cases observed in my own practice and that of former associates in which incomplete obstruction, often to a marked degree, was relieved by a régime consisting of initial purgation, repeated colonic irrigations, and an essentially non-residue diet. Strict avoidance of oral administration of barium in conjunction with roentgenoscopic examination of the intestinal tract when an obstructive lesion of the colon is suspected will, I believe, reduce materially the necessity of preliminary procedures for drainage, for unquestionably such practice is responsible for many instances of acute obstruction superimposed upon chronic obstruction of long standing. Adequate care in preparing these patients for operation, taking five to seven days or more, is, in my opinion, secondary in importance only to early recognition of the malignancy.

Emergency surgery is rarely necessary or justifiable in such cases, since obstruction, when it develops, usually is slowly progres-

sive and well tolerated even for a week or more after it becomes complete. The blood chemistry under the circumstances, in striking contrast to the findings in acute obstruction of the small intestine, may and usually does remain unaltered. On a number of occasions, in consultation with other surgeons or on visits to their hospitals, I have observed the tendency to consider as acute obstruction cases which in my experience have, in most instances, responded to a medical régime aimed at decompressing the chronically obstructed bowel. Even if the response has not been wholly adequate there can be no doubt that the patient becomes a better operative risk for cecostomy or colostomy after a period of hospitalization in which measures to overcome dehydration have been instituted. The discrepancy in statistical reports on the incidence of acute obstruction may be explained in part by a difference in the interpretation of that which constitutes an acutely obstructed colon.

In regard to standardization of technical procedures employed in the treatment of carcinoma of the rectum Cheever<sup>2</sup> has said: "Even were it desirable, it certainly is not possible completely to standardize the treatment of any disease. Such a multiplicity of variable factors is involved, in the patient himself, in his disease, in therapeutic measures, and in the physician who applies them, that any attempt at actual standardization is fallacious and unlikely to prepare the physician to meet an unusual and unforeseen situation when it arises. Nevertheless a classification of the types of a disease and a knowledge based on experience of what measures have proved best to meet each typical condition are absolutely essential to prompt and efficient action. Of no disease are these statements more true than of carcinoma of the colon, and yet, in the selection of operative measures in this condition very great divergence of opinion exists among surgeons of experience as to what methods are best."

Although standardization of surgical procedures is not wholly practical I feel with Daniel Fisk Jones<sup>3</sup> that at least some agreement as to the fundamental principles of the treatment of patients with carcinoma of the rectum can be reached. In a valuable contribution to the subject he quoted Grey Turner as having said: "The history of surgery of malignant disease is neither so discouraging nor so discreditable as many would have us believe, for it shows that when efforts of the surgeons have been *sufficiently thorough*, the results have often been commensurate with the sacrifice which the patient has had to make." The fundamental principle to be settled is: What is a "sufficiently thorough" operation?

This has been answered up to the present by two opposing groups. The first group contends that carcinoma of the rectum metastasizes late, and consequently that local operation is sufficient. The other group accepts the postulate that all carcinoma which can be extirpated should be dealt with radically not alone by its removal but by removal of the contiguous gland-bearing tissue as well. In 1912, Paul<sup>4</sup> of Liverpool, whose exteriorization measure for colonic lesions is a landmark in intestinal surgery, said: "Why should we undertake an extensive excision of the mesentery for the removal of glands which in all probability are not infected?" Similarly certain surgeons today contend that local or essentially local excision of the rectum, with or without preservation of the perineal anus, is "sufficiently thorough." The description of the pathologic anatomy of carcinoma of the rectum and rectosigmoid by Miles constitutes one of the classics of modern surgical literature and has profoundly impressed a great majority of English-speaking surgeons, and more recently certain French and Scandinavian surgeons. There is still a small group, however, which clings to the belief that local excision is adequate in all cases. I again quote D. F. Jones:<sup>3</sup> "The implication that a local or restricted operation gives as good

results as an extensive operation because a surgeon here and there has had a patient live five years or more after a local or restricted operation is without foundation in fact. Before statements about the value of any operation are made, we must know the type of growth and extent of local disease, the percentage of cases operated upon, the mortality and the number of patients living in comfort three, five, or more years. These reports of small series of cases treated by local or restricted operation without stating the percentage they are of the total number seen are discouraging to those trying to improve results and to operate upon a large percentage of cases, and it makes it difficult to do any operation other than the limited ones reported because physicians and patients hear of them and will not submit to the more extensive and, I believe, better operations in most cases." Jones further states that he had met one man who was at least honest in the matter. He admitted that he amputated the rectum by the posterior route because his mortality was lower than with the more extensive operation and, as the mortality was lower, a better impression was made on the community even though the late results were not so good.

The controversy as to what is a "sufficiently thorough" operation for carcinoma of the rectum is continued to a great extent by those who object to permanent colostomy. A fairly considerable number of physicians still object to colostomy on general principles, but among those surgeons who are particularly interested in the treatment of carcinoma of the large intestine there are very few in this country and England who do not consider permanent abdominal anus essential to any surgical procedure directed toward the cure of carcinoma of the rectum and rectosigmoid. Babcock,<sup>5</sup> however, in 1934, stated: "It is our feeling that colostomy should now be eliminated except as a palliative measure. Not only is the perineal opening convenient to take care of but it enables the surgeon, by digital examination, to locate and

remove a pelvic recurrence at an early stage." Horsley,<sup>6</sup> in 1937, in describing a technique of restoring the continuity of the bowel after resection of the rectosigmoid wrote: "Something more than mere existence should be included in the objective of surgery. If the patient can be made more comfortable and life is made to seem more worthwhile after a procedure that offers about equal chances of a cure of the cancer as other operation, it is obvious that this technique should be adopted." Pfeiffer,<sup>7</sup> in discussing a recent paper which described a procedure for restoration of the continuity of the bowel after resection of the rectosigmoid, had this to say: "It has been the dream of every surgeon interested in the surgery of malignant disease of the rectum and rectosigmoid to devise a plan which fulfills the requirements of adequate cancer surgery and at the same time permits restoration of continuity of the bowel. No artificial anus is equal to the natural mechanism. I am, however, impelled to interpolate right here that a well made and properly located colostomy in a well patient is easily managed. The chief and most vociferous objectors to colostomy are those who do not have them and do not need them to remain alive.

"It is to be hoped that no one will advocate or condone deliberate sacrifice of sound cancer surgery for any lesser consideration. Good surgery cannot be founded upon the occasional lucky case or the unusual condition. The lowest mortalities, the highest operability rates, the greatest percentages of cures are unquestionably in the hands of those whose practice it is to perform the widest removal of tissues.

"In my earlier experiences with carcinoma of the rectum and rectosigmoid I tried a number of expedients to restore continuity, but my results were such that I felt that the occasional successes did not counterbalance the increased morbidity and mortality, as contrasted with frank adoption of permanent colostomy in all but highly selected cases. Of course, the uncontrolled perineal colostomy is infinitely

inferior to the abdominal anus in all respects except sentimental nonsense."

Lee,<sup>8</sup> in discussing the same procedure, emphasized "that in our experience the patient's adaptation to a life with an artificial anus is not so difficult as is generally supposed, and that when properly made and properly cared for, which means the discarding of the filthy colostomy bag, it is possible to carry on a normal life without embarrassment to one's family or friends. I recall one patient in particular, a woman of unusual refinement, who for more than three years has been attending to all of her social duties just the same as she did before operation, and indeed as far more active than most of her friends of her age, and no one is conscious that she is carrying on with such a handicap."

With Pfeiffer and Lee I find myself in full agreement. It is my conviction, after personal contact and correspondence with many patients and their physicians in regard to their attitude toward colostomy that the average patient not only finds permanent colostomy tolerable but fully commensurate with a comfortable and useful existence. Recent contact with fifty of these patients permitted the following brief survey of their manner of living following the establishment of a colostomy: actively engaged in gainful pursuits, twenty-four; actively engaged in fraternal, church or social activities, but retired from regular work because of financial independence, nine; housewives undertaking their duties without assistance, seven; employment desired but so far not obtainable, seven. Only three considered colostomy such a handicap that they avoided both employment and social activities; six found it necessary to forego both because of debility incident to recurrence but they had been actively employed for periods ranging from five to twenty-two months. Two of these were inoperable at the time colostomy was established and one, a college professor conducted his regular



course for six months and made five out-of-town addresses before retiring.

COMBINED ABDOMINOPERINEAL  
AND PERINEO-ABDOMINAL  
RESECTION IN ONE  
STAGE

In my opinion a radical combined operation in a single stage is the preferable procedure. The local growth and its contiguous gland-bearing tissue are extirpated en masse after the manner of Miles,<sup>9</sup> or following some modification, such as the perineo-abdominal excision of Turner, Gabriel, or Rankin. More familiarity with technical details and more meticulous preoperative preparation and postoperative care have permitted Miles, Abel, Rankin, T. E. Jones and others in recent years to utalize the single-stage procedure in a much higher percentage of cases than hitherto. Abel,<sup>10</sup> of London, lists three fundamental principles of surgery involved in operating on a patient with carcinoma of the rectum and states that the only operation which fulfills these principles is the radical abdominoperineal excision introduced in 1907 by Miles: (1) Not only the growth but also all removable fields of lymphatic spread must be extirpated as widely as possible; (2) the abdominal, or aseptic field, should be dealt with before the relatively infected perineal area; and (3) before a primary growth is manipulated in any way, the blood and lymph vessels which are liable to transmit metastatic cells into the venous and lymphatic circulations should be ligated, and dissection be carried out as far as possible from the original lesion. Posterior excision following colostomy will not fulfill any of these requirements. Perineo-abdominal excision will fulfill only the first principle, since the initial approach is through the relatively infected perineal region and the segment containing the growth is manipulated prior to ligation of the blood and lymph vessels.

Gabriel,<sup>11</sup> who is the principal advocate of the one-stage perineo-abdominal operation, takes a somewhat different view from

that of Miles and Abel. Admitting the merits of the abdominoperineal excision he states that the considerable number of two-stage modifications which have been described indicates the desire and the attempts of surgeons to minimize the risks of the original operation. He enumerates the following advantages which the one-stage perineo-abdominal excision possesses over the operation of Miles: (1) it is an easier operation to perform provided the operator has the experience which enables him to do a neat perineal dissection; (2) it overcomes the serious difficulties of a narrow male pelvis, especially in those cases with a large tumor at the rectosigmoid juncture; (3) the dangers of sepsis and shock are largely eliminated—the former by avoiding intraperitoneal division of the colon, and the latter by doing the perineal part of the operation first so that no turning of the patient is required after completion of the abdominal operations; and (4) it fulfills all the requirements of a radical operation in regard to high sections of the vascular and lymphatic pedicle and, in regard to the length of bowel which is removed, is slightly more radical than the Miles technique.

I am in full agreement with Gabriel as to the existence of certain advantages with the perineo-abdominal type of maneuver, having employed a two-stage variation of this operation on numerous occasions, but disagree with his advocacy of a "blind" one-stage operation without preliminary laparotomy. Anticipating such criticism on the score of possible liver metastasis being present, he stated that in a series of twenty-nine cases his preoperative estimate of operability was substantiated. Nevertheless the most experienced surgeons will occasionally fail to realize the existence of metastasis until the abdomen is opened. Rankin reported that in 919 cases in which laparotomy was performed, over a period of six years 385 cases (41 per cent) proved inoperable because of metastasis of the liver (100 cases), general lymphatic involvement (forty-three cases), and so forth.

In many of these cases the weight of the patient was normal, determinations of the hemoglobin revealed normal percentages, and the growth was mobile, yet at exploration evidences of generalized metastasis was noted. Particularly was this true in instances of youthful individuals harboring tumors of a high degree of malignancy in accordance with Broders' classification. In 1935, Rankin<sup>13</sup> reported a series of cases in which exploration was carried out through a McBurney incision and cecostomy established; subsequently perineo-abdominal resection was consummated. I believe this maneuver has a wide field of usefulness and that it will be applicable in many instances in which the procedure of Miles would be contraindicated.

Unquestionably there are robust individuals who, carefully prepared and selected, may withstand a formidable procedure in one stage which would prove entirely too strenuous for one less vigorous or more advanced in years. Collier and Ransom,<sup>14</sup> in 1936, stated that their mortality rate was only 8.3 per cent in forty-eight combined abdominoperineal operations done in one stage. With an increase in the operability rate the mortality likewise rose. Their first cases were elected with great care; subsequently they accepted for operation patients aged more than 60 years and of these seven died, six as a result of pneumonia or heart disease. Their early experience strikingly emphasizes the fallacy of deductions based on a small series of selected cases; their later experience convinced them of the advisability of returning to a somewhat more conservative selection of patients for the radical operation.

#### COMBINED ABDOMINOPERINEAL AND PERINEO-ABDOMINAL RESECTION IN TWO STAGES

For the less favorable risks—and this is a fairly numerous group of cases—a two-stage operation is indicated. More specifically, the indications for such a procedure are: (1) local complications such as an

unusually large growth with little mobility, fixation to adjacent viscera or structures, or definite evidence of infection about the growth; (2) where double resection of the large and small bowel or bladder is required; (3) anatomic types such as extreme obesity; (4) coexisting debilitating diseases such as diabetes and cardiorenal vascular diseases; and (5) senility, i.e., in most patients who have passed 60. Obstruction unrelieved by preoperative medical measures will, of course, require preliminary drainage, which is usually by cecostomy, but upon relief of the obstruction, if there is no other contraindication, a one-stage combined type of maneuver may be elected. Many growths deemed inoperable at primary exploration recede to such an extent after the sidetracking of the fecal current and constant irrigation that radical operation becomes feasible and results are entirely satisfactory. Fixation has resulted more often from inflammatory reaction than from malignant extension.

The two-stage combined operations now popular vary somewhat in technical details and in scope, but the fundamental principles of all of them may be traced to the classic one-stage procedure of Miles. The type advocated for many years by Daniel Fiske Jones<sup>15</sup> has much to recommend it. An advantage which it possesses is that a radical procedure is carried out at the first stage without the necessity of opening the bowel; a disadvantage is that loop colostomy is established. The results, both immediate and remote, as reported by Jones, have been excellent, and their significance is enhanced by the accurate and detailed presentation of the statistics.

Rankin,<sup>16</sup> in 1929, described a procedure in which at the first stage a single-barreled or end colostomy is made and the divided distal end is inverted and dropped back; at the second stage a perineo-abdominal excision is consummated. One year later Lahey<sup>17</sup> modified this operation by bringing the lower end of divided sigmoid out of the exploratory incision for purposes of irrigation between stages. I have not employed

this modification because of the belief that if obstruction was present one divided the bowel at greater increased risk and if obstruction was not present in a marked degree, irrigation could be arranged with a two-way tube in the rectum just as satisfactorily. Moreover, Lahey's method necessitates, at the second stage, inversion of the end of bowel which he now brings out of a stab wound, and the peritoneal cavity is subjected to possible contamination from this source.

Because of the many disadvantages of the Coffey operation, I see no advantage in its employment under any circumstance. The mortality attending this procedure, judging from recent reports, is prohibitively high. From the technical standpoint it may be impossible to telescope the distal end of the bowel through the constricted lumen of the rectum at the site of the growth, and failure of collateral circulation may and not infrequently does give rise to necrosis of the inverted distal end of bowel and pelvic cellulitis. In a series of twenty-six cases of anterior resection of the rectosigmoid, reported by Rankin,<sup>18</sup> in 1928, three instances of failure of the blood supply to the inverted and retroperitonealized upper portion of the rectum were encountered. As in the Coffey procedure the superior hemorrhoidal artery was ligated. As a consequence of this complication the employment of the procedure was soon discontinued.

#### COLOSTOMY AND POSTERIOR RESECTION (PERINEAL EXCISION)

For growths beneath the peritoneal reflection, particularly if low in the rectum, this procedure is satisfactory from the standpoint of operative mortality and the comparative ease with which it can be accomplished. On the other hand, this operation does not permit excision of the node-bearing tissue in the vicinity of the rectosigmoid and in the mesentery of the sigmoid as thoroughly as by the combined abdominoperineal maneuver. The high rate of recurrence following perineal

excision led Miles to design the combined operation. In his series of fifty-eight survivals of perineal excision, fifty-five were known to have died from recurrence, a rate of recurrence of 94.8 per cent. While it is still true that recurrence is more frequent after posterior excision than when the radical combined maneuver is employed, nevertheless there is ample statistical proof that the former can be carried out in a group of cases which are such grave operative risks that the latter is not to be considered. Five-year cures of 38 per cent have been reported in 300 cases (Rankin<sup>19</sup>) and 50 per cent in 209 cases (Lockhart-Mummery<sup>20</sup>).

Owing chiefly to the efforts of Lockhart-Mummery, perineal excision has been changed from a purely palliative procedure to one of distinct usefulness in the cure of lower rectal growths in instances in which the more radical operation is contraindicated. He emphasized the fact that operation usually has to be performed on elderly persons and on those who, either because of their age or other infirmities are not very good surgical risks. One hundred thirty-seven of his patients were aged more than 60 years, and thirty were over 70 years. In 167 cases from his private practice there were only six deaths, a mortality of less than 4 per cent. Of 209 patients in whom operation was carried out five years or more previously, approximately 50 per cent survived as five-year cures.

Contrary to an apparently widespread belief, Lockhart-Mummery<sup>20</sup> neither advocates nor employs perineal excision to the exclusion of all other procedures. He states that his operative procedure is suitable in any case in which the growth is at the anus or anywhere in the rectum proper, provided it is not fixed to important structures; it cannot be performed if the growth is at or above the rectosigmoid junction unless the growth is small and the sigmoid fairly lengthy. A high growth, he states, ordinarily "should be removed by an abdominoperineal operation, or if the surgeon finds himself in difficulties owing to the fact that

the growth is too high to be removed safely from the perineum, he may reverse the procedure, and after freeing the rectum below, close the posterior wound, turn the patient on his back, and complete the operation from the abdomen—in short, do a perineo-abdominal resection.”

#### ANTERIOR RESECTION OF THE LOWER SIGMOID AND RECTOSIGMOID

Neoplasm situated low in the sigmoid occasionally constitutes a separate problem. It cannot be exteriorized without extensive mobilization of the rectosigmoid, hence the patient is subjected, as a rule, to abdominoperineal operation of some type. From the standpoint of curing the disease such a course is entirely satisfactory but there are instances, admittedly rare, in which a more conservative procedure without sacrifice of the rectum probably is justifiable. If the growth is situated well within the peritoneal cavity, at least 5 cm. from the reflection of the peritoneum on the bowel, an obstructive resection with subsequent restoration of the continuity of the bowel may be considered, provided that: (1) the growth is small and of a low grade of malignancy (grades 1 and 2), as determined by biopsy through the sigmoidoscope; (2) the growth is a polypoid one of doubtful benignancy; or (3) the patient refuses permanent colostomy. However, not infrequently factors are present which make such a procedure inadvisable, chief among which is marked inflammatory reaction or formation of abscess in the vicinity, marked adiposity, and instances of a short sigmoid flexure. In 1936, Rankin and I<sup>21</sup> described for the low sigmoid lesion a modified obstructive resection, employing the Rankin clamp. David<sup>22</sup> previously had described a similar procedure which differed somewhat in the details of technique. Although convinced that these procedures may be employed advantageously in certain carefully selected cases, we did not lose sight of the fact that even in instances of low sigmoidal growths the ideal procedure, in the absence of contraindications,

is a combined abdominoperineal operation, either in one or two stages. With Pfeiffer<sup>7</sup> we feel that the occasional success which attends anterior resection of the rectosigmoid does “not counterbalance the increased moribidity and mortality, as contrasted with frank adoption of permanent colostomy in all but highly selected cases.” For growths which are situated in the rectosigmoid at or below the reflection of the peritoneum onto the bowel we believe a combined operation is invariably the maneuver of election.

#### SACRAL (OR KRASKE) RESECTION OF RECTUM

Sacral operations, which entail establishment of a perineal anus, have rarely been employed in this country or England in the last two decades, but on the continent, particularly in Germany and Austria, until very recently the sacral route has been used almost to the complete exclusion of all other maneuvers. Operative and recurrent mortality and the percentage of poor functional results have been excessively high. Only quite recently have a few surgeons in this country commenced again to advocate resection of the rectum which provides a perineal rather than an abdominal anus.

Although technically it might be designated as the Kraske type of procedure, the operation devised by Babcock<sup>5</sup> is as different from the traditional Kraske resection as Miles' operation is from the early perineal excision of the rectum. Babcock's operation is probably almost as radical as that of Miles and differs essentially from the latter in only one respect, namely, that a perineal anus is established rather than an abdominal one.

#### CONCLUSIONS

My intention here has not been to urge the most radical, hence the ideal operative measure in every instance, but with Daniel Fiske Jones I make a “plea for a ‘sufficiently thorough’ operation for every patient who can stand it.” It is also my belief

that the saying "that the smaller and the earlier the growth and the better the chance of a cure, the more extensive should the operation be" holds good today as well as formerly. As T. E. Jones<sup>11</sup> recently stated: "It is an error to perform small operations for small cancers and big operations for big cancers: perhaps better results would be obtained if the plan were reversed." There will always be patients who are not sufficiently strong to withstand the ideal operation and many surgeons have not had sufficient experience to undertake it.

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# THE PATIENT WITH A CARCINOMA OF THE COLON OR RECTUM

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TO inform a patient that he has a malignancy of the large bowel or rectum is a task of great responsibility and requires a most sympathetic understanding of the psychology of the patient. Perhaps in the stress of practice the physician all too frequently fails to estimate the "blow" that is given to a patient when he is informed for the first time that he has a cancer. On numerous occasions I have tried to place myself in the position of the patient and to estimate as fully as I could the various factors that enter into the reaction of the individual.

Many years ago a very distinguished doctor told me that the surgeon who first tells an individual he has a cancer of the stomach or bowel seldom performs the surgery. The doctor proceeded to elaborate his idea as follows: the first reaction of the patient when informed of a malignancy is to have the diagnosis controverted by another opinion and even a third or fourth. After the patient has received two or three similar verdicts as to the seriousness of his condition the effect of any further confirmatory opinion does not occasion the spontaneous resistance that is brought forth when the first opinion was rendered.

It would therefore seem wise to analyze some of the emotional reactions that must be brought forth when an individual is faced with the necessity of considering surgery for a neoplasm of the large bowel. The questions that are usually asked, in the order of their importance, are: (1) Can the condition be cured? (2) How long will it take to get well? (3) What are my chances of surviving? (4) Will I have normal bowel function after the operation? After these questions are canvassed, the matter of

expense and financial outlay presses for solution. Aside from such neoplasms as may be resected in one stage without loss of normal evacuating function the problem of malignancy of the large bowel is one that must consider the number of operations, the concomitant colostomy—either temporary or permanent—and the prolonged convalescence and withdrawal of the individual from his occupation or business.

How often have we heard the cry "I would rather die than have a permanent colostomy"; as a matter of fact, we have heard the same expression used by our colleagues and our professional friends. If the general practitioner takes such an attitude he will not be very optimistic in advising a patient with a carcinoma of the rectum to accept a splendid and properly executed surgical procedure which must carry with it a permanent colostomy.

However, it is important for the surgeon to recognize that in dealing with neoplasms of the large bowel and rectum the patient has an utterly different psychology from that which obtains in other surgical conditions. Cancer of the bowel is as frequent as cancer of the stomach but with a much greater prospect of cure. In cancer of the stomach the resection and reconstruction of alimentary continuity is established by a one-stage surgical procedure. A neoplasm of the bowel, however, involves a consideration of multiple operations, one or two-stage procedures, artificial anus and a prolonged convalescence with pain and discomfort, to say nothing of the abnormal mechanism for evacuation of the bowel. No other intra-abdominal surgical condition is attended with such a detailed consideration of so many factors. Therefore,

the surgeon must evaluate the patient's emotional sensitivity and his psychological equipment when discussing the details of his condition.

There is another and very important aspect of this subject. That is the question of secrecy. In newspapers, lectures and by radio all types of indigestion are freely discussed. In fact, cancer of the stomach invites widespread discussion in polite society. But how seldom are the complaints of the large intestine and rectum discussed and how infrequent is the presentation of the problem of malignancy of the large intestine, even at our medical societies. When these factors are combined with inherent modesty or affectation of prudery, it is not to be expected that an individual with colon symptoms will come to his doctor as readily as will those suffering from indigestion. Even the presence of blood in the stools will be tacitly assumed to be due to a hemorrhoid. There seems to be an inherent secrecy and attempt upon the part of the patient to disguise or to defer the recognition of symptoms until by their very prominence they at length force notice upon the individual.

Given three persons—one with carcinoma of the stomach, one with carcinoma of the colon and one with carcinoma of the rectum, it may be fairly assumed that the individual with carcinoma of the stomach will ordinarily have an entirely different reaction and psychology when informed of his condition than the other two. The patient with carcinoma of the colon will be on the whole more hopeful and optimistic than he with carcinoma of the rectum. The patient with a malignancy of the rectum who must pay frequent visits to the toilet to expel small quantities of feces, mucus and blood, with the rectal irritability and the unwarranted terror of a colostomy, represents a real psychological problem.

Innumerable people accept the aid of eyeglasses; a few of the deaf desire the additional help of an audiphone; but the thought of a colostomy as a means for

the prolongation of life and part of the price that must be paid for a surgical cure of a neoplasm of the rectum seems to be unacceptable to many patients with malignancy. A colostomy is not a pleasant life companion, but it does not sentence the individual to social ostracism; one may live a relatively normal and useful life. It requires no bag, or particular apparatus, but does demand attention, education and training. The patient with a colostomy must spend a certain time each day in the care of it and must regulate his diet and habits to avoid accidents.

Patients react in varying degrees when told that they require surgery, but one and all react with fright and terror at the thought of a colostomy. It seems to be that here is a problem which requires sympathetic approach and counsel. I believe it is highly desirable to impart the information about cancer of the rectum by stages and not all at one time, and that it is a mistake to operate upon an individual for carcinoma of the rectum without a full understanding of the nature of and reasons for a colostomy. Psychologically, the patient gradually adapts himself to the sum total of all of the disturbing information and with the advice of the physician will rationalize his thoughts so that he will meet the prolonged siege and surgical procedures with optimism and hope.

It has been our experience that patients face the future after a surgical procedure for neoplasm of the large bowel and rectum if they are assured that the tumor has been removed. The late Dr. Jones of Boston made the observation that in his experience he had no suicides among individuals from whom he had removed the tumor, whether they had recurrence or not; but he had suicides among some of his patients if the tumor was not removed and only a colostomy had been performed.

Practically every individual in the cancer age has had some personal contact, either direct or indirect, with some person who has died a "cancer death." This has

affected his viewpoint and conditioned his reactions to the thought of "dying by inches." I recall one patient, a woman in her middle fifties upon whom I had operated previously. One day she came into my office with a history of rectal pain and bleeding. At the first interview I told her it was necessary to localize the source and place of the origin of the blood. On sigmoidoscopic examination it was readily determined that she had a malignancy of the upper portion of the rectum. A biopsy specimen was taken at the same time and I casually remarked that I would send the specimen to the pathologist to be examined. After a few days the histology of the specimen was determined and with the report of the pathologist before me, I entered into what I considered the most sympathetic and tactful form of approach, as to the desirability of removing the tumor and that the operative mortality was not great, and that she had at least a 50-50 chance of outliving her present condition. The thought of malignancy as such I do not think was the disturbing factor but the permanent colostomy was the hurdle that she could not, or would not take.

In the non-obstructive lesions of the cecum and ascending colon which are associated with depreciation of health, the approach to the question of malignancy can best be made by a consideration of the patient's general physical condition and disability. Ordinarily there is no necessity for haste. A week or ten days or two weeks spent in arriving at a plane of mutual acquiescence, provides a more willing and cooperative patient, and is more helpful than an appearance of haste on the part of the diagnostician.

After the surgery has been performed and the patient has survived the surgical trauma, particularly in the presence of a colostomy, great demands will be made upon the patience of the individual. This is particularly true with patients who have a temporary colostomy following an obstructive resection of the Mikulicz type. The

importunity of the patient to have the bowel closed will make increasing demands upon the resiliency of the surgeon and there will be required of him a great degree of fortitude in the face of the demands to "close the d— thing." It seems well, therefore, that the patient should be repeatedly informed that the time element is not a matter of days, or weeks, but may cover some months. Uniformly better results have been obtained in my practice by delays that were the result of long holidays than when I succumbed to the blandishments of the patient and tried to expedite matters by forcing repair or closure.

It is obvious that the complete conduct of a case of colon or abdominoperineal resection with colostomy is a long job and with the rarest exceptions will not bring adequate remuneration and payment. One cannot dismiss a patient after a Miles operation without entering into the most minute details of his personal and conjugal life. Repeated explanations must be given of the importance of certain articles of diet and the reasons for certain minor complications, such as the inability of the patient to express freely the irrigating fluid after it flows readily into the colostomy. A few words of explanation: that this is due to contracture of the orifice; that it requires a "V" excision of the skin to enlarge the orifice, etc., will demand additional patience upon the part of the doctor. Again, the vesical symptoms after resection of the rectum may be most distressing to the patient. A sympathetic attitude at all times, together with a willingness to explain things, will do much to establish the patient's morale.

Does the surgeon realize the mental anguish of a patient with chronic diverticulitis of the sigmoid? Here is a condition, except for its complications, best treated by a medical regimen. From time to time there is an exacerbation of symptoms—pain and tenderness. The patient realizes the dangers of perforation and abscess formation. With each attack relatively the



same advice is given. Finally, the patient with a spirit not unlike that of the gambler presses for surgical relief. Under such circumstances the surgeon must not only show great spiritual courage but must inculcate the same fortitude in the patient. To say "no" to importunities for surgical intervention is a higher tribute to the

physician's skill and character than to acquiesce.

Finally, it would seem that in no field of surgical endeavor are the psychic factors of the surgeon's advice so important as in surgery in the large intestine and rectum. The patient needs not only a surgeon but a counselor and a friend.



THE only benign tumors of the rectum and colon which one encounters with any frequency are the adenoma or mucous polyp, originating from the columnar epithelium of the mucosa, and the squamous polyp, which results from hypertrophy of an anal papilla.

# IMMUNIZATION OF THE PERITONEUM\*

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SINCE the advent of major abdominal surgery the problem of postoperative peritonitis has been an extremely important one and still presents itself as a challenge to the surgeon from the standpoint of both prevention and cure. During the past fifty years there has been a large amount of work done on the production of peritonitis in various experimental animals, and attempts have been made to correlate the findings in animals with the peritonitis which occurs in the human being. Such attempts have been far from satisfactory and there is still need for more carefully controlled laboratory and clinical investigation in the field.

The early workers on experimental peritonitis found it difficult to produce a true fibrinopurulent peritonitis by the intraperitoneal injection of bacteria. They could easily produce a bacteremia, or, with more virulent organisms, could get a lethal effect, but not a peritoneal exudate. It therefore occurred to them that peritonitis per se was probably not the cause of death, but was in reality a protective mechanism, and that the animals, paradoxically enough, died from a want of inflammatory reaction rather than as a result of it. Herrman, in 1927, at the Mayo Clinic, showed that in order to produce a peritoneal exudate in the rabbit it was first necessary to build up an immunity before injecting the infecting material. This was successfully carried out by using repeated small intraperitoneal doses of a vaccine prepared from the colon bacillus and *Streptococcus viridans*. At autopsy the animals showed a true fibrinopurulent peritonitis, but control animals which received no such immunizing vaccine died

promptly with no visible evidence of peritonitis. Today, this concept regarding the production of peritonitis is generally accepted, and comes to our attention every time we perform an abdominal operation. We know that the degree of resistance of the peritoneum will vary with the extent to which the peritoneum has been previously immunized. In cases of regressing acute cholecystitis, in which pus is spilled into the peritoneal cavity at operation, there is no grave danger from a subsequent severe peritonitis. This resistance of the peritoneum to a limited amount of infection is probably not due to any "natural" or "inherent" immune quality, but is more likely the result of an excellent blood and lymphatic supply.

Attempts to immunize the peritoneum by the intraperitoneal injection of vaccines and various foreign substances are by no means new. As early as 1887 Pawlowsky used croton oil to produce peritonitis in experimental animals. The problem was more actively studied by Issaef in 1894 when he introduced the idea of vaccination to prevent postoperative peritonitis. Pierralini, in 1897, found that a leucocytic exudate could be produced by the intraperitoneal injection of sodium chloride and other inert substances. In the same year Garnier demonstrated that bacteria were rapidly destroyed in the presence of such a leucocytic exudate in the peritoneal cavity, and his researches revealed a new concept regarding the mechanism of protection from an otherwise fatal peritonitis, namely phagocytosis. In 1902, Solieri, working on the theory that "immunity" was a result of phagocytosis, produced a peritoneal leucocytic exudate, and found that animals

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with such an inflammatory reaction of the peritoneum survived a colon bacillus peritonitis.

The problem of peritoneal immunization was reopened in this country by Steinberg and Goldblatt in 1926, and since then they, working together and individually, have done a large amount of research on this phase of peritonitis. Their earlier experiments showed that intraperitoneal immunization by living and heat-killed colon bacilli produced an immunity to subsequent colon bacillus and fecal peritonitis. Later, in a series of experiments in which they studied the cause of death in peritonitis, they presented convincing evidence concerning the rate of passage of bacteria from the peritoneal cavity into the lymph and blood streams. Working with dogs, they found that when colon bacilli in saline suspension were injected intraperitoneally they were rapidly absorbed into the blood and lymph, and that such animals practically always survived. However, when equal doses of the colon bacillus were suspended in 1 per cent gum tragacanth, the animals did not get a bacteremia, but invariably died. The hypothesis was therefore formulated that toxic products of the bacteria were formed in quantity only when they were retained within the peritoneal cavity, and that such toxic products were the cause of the death of the animal.

Concurrently, David and Sparks, in 1927, threw further light on the mechanism of absorption of bacteria, and helped to establish the belief that peritonitis serves a protective function. They showed in animals that when colon bacilli were injected intraperitoneally they passed readily into the blood and lymph. When, however, a plastic peritonitis was first produced by injection of a turpentine emulsion, organisms subsequently injected intraperitoneally could not be recovered from the blood stream or thoracic duct.

Peritoneal "immunity," so-called, is probably not a true immunity but a local form of protection which manifests itself as a reaction of the peritoneum to trauma and

infection. In this connection, most students of peritonitis feel that phagocytosis plays an important protective rôle. There is, however, no uniformity of opinion regarding the relative protective functions of the polymorphonuclear leucocytes and the large mononuclear cells or histiocytes.

Since his earliest studies, Steinberg has contended that the protection secured from intraperitoneal vaccination is a result of phagocytosis of otherwise harmful bacteria. He regards the polymorphonuclear leucocyte as the important cell serving in this capacity, and has designated this type of protection "hyperleucocytic pre-immunity." He feels that the histiocyte is a "scavenger" cell which appears relatively late in peritonitis, where it can be demonstrated to engulf degenerated polymorphonuclears in this stage of the disease. He has emphasized the point that the polymorphonuclear cells act early in carrying out their phagocytic function.

At the Mayo Clinic the opinion has prevailed among the various workers that the histiocyte is probably the most important cell concerned with phagocytosis. Hermann early expressed this belief in his work on rabbits and since then it has been supported by other investigators. In 1933, an interesting study on the peritoneal fluid of man was carried out by Rixford. He had an opportunity to study the peritoneal fluid in patients at operation which had previously received intraperitoneal vaccine, and to compare these findings with a control group of patients which had received no vaccine. Specimens were taken with a glass pipette just after the peritoneal cavity was opened. In unvaccinated cases, the total white cell count averaged from 1,900 to 2,600 per c. mm. of fluid. There were practically no neutrophiles, very few eosinophiles and basophiles, but many lymphocytes and histiocytes (45 per cent). In patients who had been vaccinated 24 to 144 hours prior to operation, specimens of peritoneal fluid were also examined. There was considerable variation in the findings, but it was apparent that there was an early

increase in polymorphonuclear cells and a delayed but nevertheless marked increase in histiocytes.

The cell counts of the total peritoneal fluid have been carefully made by Seeley, Higgins, and Mann. Working with rats, they used various substances to evoke a peritoneal reaction, and then removed and weighed all the fluid present, in addition to making differential cell counts. Following injections of amniotic fluid concentrate, Barga's vaccine (prepared from colon bacilli and nonhemolytic streptococci) and sodium ricinoleate, they found that with all materials there was an early and rapid rise of polymorphonuclears, reaching a maximum in three to six hours. Histiocytes appeared much later, but, were the preponderant cells after six or seven days. The response of both cells was greater in those animals receiving sodium ricinoleate.

In 1937, Corwin, working with rabbits, reported that the cellular responses to Barga's vaccine and sodium ricinoleate were nearly identical qualitatively. The intervals for maximal cellular reactions varied, however. With Barga's vaccine, the cell count of the peritoneal fluid was greatest at twelve hours, with 1 per cent sodium ricinoleate at twenty-four hours, and with 2 per cent sodium ricinoleate at forty-eight hours. The differential count again showed that polymorphonuclears appeared early, being in greatest abundance in six to twelve hours, while the histiocytes were maximal in one to three days.

It is apparent from the above studies that variation in opinion regarding the relative phagocytic properties of the neutrophils and histiocytes is due in part to the use of different species of animals by various workers. The type of material used to evoke a reaction, the dosage employed, and the time intervals for examination of the fluid are also inconstant factors which must be evaluated in arriving at a definite conclusion.

In order to prove or disprove the value of any of the numerous agents that have

been used to immunize the peritoneum, it would be necessary to use such an agent in a very large series of patients having major abdominal operations, and at the same time have an equally large number of similar cases as a control group. As yet no such investigation has been reported. However, during the past ten years there are three immunizing agents which have been employed more extensively than numerous other substances. These are (1) the vaccine developed by Steinberg and Goldblatt, (2) the vaccine prepared by Barga, and (3) the amniotic fluid preparations originally suggested by Johnson.

Steinberg and Goldblatt, working on the idea that a marked leucocytic reaction in the peritoneal cavity could be more easily produced by some agent which prevented a rapid absorption of bacteria, developed a protective emulsion which they have called coli-bactragen. This preparation has since been modified by Steinberg, and his formula for the more recent preparation is as follows:

Tragacanth.....	1.5 Gm.
Aleuronat.....	0.5 Gm.
Escherichia coli (30 c.c.)..	2,400,000,000
Salt solution 60.85 per cent	100 c.c.

Today there is ample evidence that this emulsion will protect the experimental animal from certain types of subsequently induced peritonitis. Steinberg has succeeded in demonstrating protection against living colon bacilli, streptococcus fecalis, B. pyocyaneus, and clostridia welchi, in both pure and mixed cultures.

In the collected series of 400 patients receiving coli-bactragen which were reported by Goldblatt in 1934, eight post-operative deaths were recorded, but only three of these could be attributed to peritonitis. In the majority of patients who were operated upon by various surgeons, a resection of a part of the large bowel was performed. The preparation employed was injected intraperitoneally about forty-eight hours before laparotomy was performed and was frequently accompanied by a rather severe general reaction. The patient

was occasionally so sick from the vaccination that operation was necessarily postponed. The series was too small, however, to permit any conclusions regarding the efficacy of the vaccine. The more recent preparation of coli-bactrugen is an improvement over the former one, not only in that it produces a less severe general reaction, but has the additional advantage of achieving its maximum protection within a few hours, thereby permitting its being introduced at the time of operation. Steinberg has found that the period of maximum protection is shortened by using formaldehyde rather than heat to kill the colon bacilli.

In 1935, Potter and Coller reported their results on a series of patients who were given coli-bactrugen prior to operation. In seventy-nine patients, most of whom required major operations upon the colon, there were eleven deaths, but in only one could the fatal outcome be definitely attributed to peritonitis. They noted that the peritoneal reaction varied from a mild hyperemia to an abundant exudate resembling that of a fibrinopurulent peritonitis. Although the series of cases was too small to permit definite conclusions, they were of the opinion that the value of the vaccine was questionable except in cases of gross fecal contamination. In 1936, Coller and Ransom reported the use of coli-bactrugen in seventy-nine cases which had a combined abdominoperineal resection for carcinoma of the rectum and rectosigmoid. There were twelve deaths, but in none could death be proved to be the results of peritonitis. In the same year Steinberg reported 391 cases in which coli-bactrugen was used preoperatively or at the time of operation, with none developing postoperative peritonitis.

In 1928, at the Mayo Clinic, based on experimental work done by Herrmann, Barga developed a vaccine prepared from streptococci and colon bacilli. The vaccine was given three days before operation involving intestinal resections. In 1935 Dixon and Barga reported having used the

vaccine in 1,500 such cases, with a reduction of 66 per cent in the mortality rate from postoperative peritonitis. The reaction from the vaccine usually consisted in a temperature elevation to 102° or 103°F. which receded in a gyrating fashion and returned to normal twenty-four to thirty-six hours after vaccination. In 1930, Rankin, in a review of 527 surgical lesions of the large intestine and rectum in which peritoneal vaccination was used preoperatively, reported a mortality rate of 12.3 per cent by patient and 8.6 per cent by operation. In 1933, he began a new series of operations upon organic lesions of the colon and rectum in which the vaccine was not used. In 200 consecutive operations upon 130 patients he reported a mortality rate of 5.5 per cent by operation and 8.4 per cent by operation. Rankin has attributed the decline in mortality to better preoperative preparation rather than to vaccination.

Johnson, in 1922, first conceived the idea of using amniotic fluid to prevent postoperative adhesions, and since then he has used it as an agent to assist in the processes of peritoneal defense and repair. While the use of a substance which allegedly prevents adhesion formation but at the same time protects against peritonitis seems paradoxical, Johnson explains that the action of amniotic fluid on the peritoneum is to produce a protective layer of fibrin on the serous surfaces and a moderate local leucocytosis, which is followed later by a complete resolution of the fibrinous deposit. The amniotic fluid used is obtained from cows two to five months pregnant. It is sterilized by the Berkfeld filter method. Johnson is of the opinion that amniotic fluid provokes a peritoneal reaction which is entirely within the limits of safety, gives an early response, and produces only a minimum physiologic disturbance. He describes the peritoneal reaction as a "defense response characterized by hyperemia, marked subserous edema, increase in peritoneal fluid, and the formation of a pink-tinged fibrinous exudate. There is an increased white cell count

which rises rapidly for about twelve hours, at which time the differential count shows a marked preponderance of polymorphonuclear leucocytes. Having reached its peak, the white cell content of the exudate gradually recedes and the neutrophils are replaced by the histiocytes. The total white cell count finally becomes preponderantly histiocytic." He states that when the exudate is removed from the peritoneal cavity it quickly forms a fibrin clot. By contrast he points out that following the intraperitoneal injection of vaccines there is a very severe reaction characterized by a profuse hemorrhagic exudate which does not clot upon removal and exposure to air.

Johnson's work has been collaborated in by Warren, Trusler, Young and Marks, Kimpton and others. In 1934, Young and Marks reported on the use of amniotic fluid concentrate in forty-nine cases which involved, for the most part, operations on the large intestine. There were three deaths, but in only one instance could death be attributed to postoperative peritonitis. In a series of forty-six similar cases in which amniotic fluid was not used preoperatively they reported eight deaths, or a mortality of 17.3 per cent, from postoperative peritonitis. In the latter group, when they included only the cases in which the bowel was resected, there was a mortality of 38 per cent. In 1936, Gepfert reported on the use of concentrated fractions of bovine amniotic fluid (amfetin, Lilly). He was of the opinion that patients receiving amniotic fluid had a smoother postoperative course than did a similar group of control patients.

Further studies in nonspecific peritoneal immunization were reported by Morton in 1931. He used various substances to vaccinate the peritoneum, particularly dextrose broth, heated streptococcus filtrate, various solutions of glucose, and sodium chloride. Using rabbits, he found that he was able to establish a certain degree of protection in most of the animals at the end of sixty hours, and, at the end of

several days, "immunity was proved in 100 per cent."

The use of bacteriophage has given a variety of results, both experimentally and clinically. Rice gave a negative report of his work on local immunization by the use of bacteriophage in 1933. Immunization of the peritoneum of dogs was attempted by injecting intraperitoneally a mixture of staphylococcus, streptococcus, and *B. coli* bacteriophage filtrates. The animals were given bacteriophage before or at the time of operation, which consisted in tying off the cecum in order to produce peritonitis. Under the conditions of the experiments, it was found that the bacteriophage failed to immunize the peritoneum. Moreover, it seemed to inhibit the formation of plastic exudates when used before or during operation. Rice expressed the opinion, however, on the basis of previous clinical experience, that bacteriophage was of value in treating abscesses which were well walled off.

Jern, Harvey, and Meleney, working with mice, reported in 1932 on their use of bacteriophage to protect against colon bacillus peritonitis. They found that they were able to protect the animals against such an infection, even when they used doses twenty-five times the lethal dose for normal controls. The phage was effective when used intraperitoneally before, during, or even several hours after the injection of the colon bacilli.

It is apparent that numerous difficulties are encountered when one studies the problems connected with the use of bacteriophage. There is a marked difference in the susceptibility of various strains of the colon bacillus to lysis by bacteriophages. Against the streptococcus, which is probably the second most common, and one of the most virulent, organisms causing peritonitis, there are few active bacteriophages. Moreover, the behavior of a bacteriophage is unpredictable; it may fail to cause lysis of a particular strain of organisms but at the same time be effective in causing lysis of unrelated bacteria. At present it cannot be

said that there is sufficient clinical evidence to prove the value of any of the single or combined bacteriophages, but there are sporadic reports of success in treating a relatively small number of peritonitis.

Filtrates have been used several years to immunize the peritoneum, but up to the present time there is very little evidence, either experimental or clinical, to indicate that they are of value. Further work will be necessary to elucidate regarding their present contradictory status.

In spite of the fact that there has been a large amount of thorough experimental work on the immunization of the peritoneum, there still remains a wide gap to be filled if our experimental knowledge is to be applied to the human being. Such factors as the species of laboratory animal used, type and dose of immunizing substance employed, and the time and mode of its administration, make it difficult to compare the findings of one investigator with those of another. It is logical to assume that the peritoneum of one animal will not react in the same manner as the peritoneum of another, and that they will all differ in some respects from that of the human. Any absolute proof regarding the value of immunization in the human would necessarily depend upon results obtained in a very large control group of similar cases in which no immunizing agent was used. As yet no adequate control series has been reported.

From a clinical viewpoint, the newer concept of the protective value of the exudate in peritonitis has a practical value. In operations done upon patients with peritonitis it would seem harmful to carry out manipulations designed to wipe or wash away exudate that is part of a protective mechanism against the infection. If free exudate is removed it must be done in the gentlest fashion by careful aspiration.

#### CONCLUSIONS

We can see no reason for the routine use of any of the substances suggested to increase the immunity of the peritoneum.

If patients are properly prepared for operation, and if the operation is carried out with careful meticulous technique, peritonitis rarely supervenes. We do feel that the use of some substance that will produce rapid local leucocytic response is of value in those instances in which, because of accident of operation or disease, the large bowel is opened. Our own experience in these circumstances has been most extensive and most satisfactory with colibactragen (Steinberg). We feel that it has a distinct value when used in the contaminated stage, and that it has little or no value once the infected stage is established. Postoperative peritonitis in clean cases is usually due to errors of operative technique that cannot be corrected by the introduction into the peritoneum of anything except better surgery.

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# SYMPATHECTOMY IN MEGACOLON (HIRSCHSPRUNG'S DISEASE)\*

## A DISCUSSION

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**N**UMEROUS types of medical and surgical treatment have been suggested in the treatment of Hirschsprung's disease. No attempt is made here to enumerate the various theories advanced as to its cause, nor to evaluate any of the treatments except sympathectomy. When megacolon is met with during an abdominal emergency, it must be treated in the best method known to the surgeon, as suggested by Whitaker.<sup>1</sup> When a case under investigation developed what appeared to be an acute obstruction, a cecostomy was done, followed by aseptic electrosurgical resection and colectomy. Colectomy is not a new procedure in idiopathic colon, but it should not be necessary. This does not apply, however, to dolichocolon.

To clarify the existing confusion regarding the condition known as megacolon or Hirschsprung's disease (in either case an enlarged colon) attention should be directed to variation of megacolon. While there is some difference of opinion, it can be said that there are two types. In one the colon is extremely long (dolichocolon) with a long mesentery. This, because of its length, is extremely mobile and therefore likely to hang down over the more fixed portion at the upper end of the rectum. This results in a kinking of the tube at that point, much as a thin-walled rubber hose would act. Gas and fecal material collect proximal to the bend and there is a resultant dilatation and hypertrophy of the colon. This is a common finding during an abdominal section in these cases. An enormously distended colon with a thickened and hardened wall is often seen as far down as the brim of the pelvis, while from

that point distally the gut is normal in size. It is this type of case which has given the most trouble in attempts to secure relief by resection of the superior hypogastric plexus (presacral nerve). It is not to be confused with true Hirschsprung's disease in which no natural bowel movement has taken place since birth. This is not true in cases of dolichocolon.

The second type, or idiopathic megacolon (Hirschsprung's disease) presents a colon the mesentery of which is probably still a normal length. The length of the colon is accounted for by the enormous distention of the pelvic colon. In this condition we are probably dealing with a hypersensitive or overactive sympathetic nerve reaction which, it is thought, causes a hypertonic spasticity at the pelvirectal flexure and the internal rectal sphincter, with ensuing achalasia. The opposite of this condition may be the causative factor, viz., a hypoactive sacral outflow (parasympathetic).

While resection of the lumbar paravertebral ganglia, or extirpation of the superior hypogastric plexus has been tried in both conditions, it is in the last described one that the best results have ensued. It is also in the idiopathic (so-called) megacolon that occasional good results have followed a spinal anesthetic and carefully conducted régime thereafter.<sup>2</sup> My experiences with spinal anesthesia have not been so satisfactory as those of others, but cases in which it has failed have responded to sympathectomy. It is, of course, possible that true dolichocolon was present, in which event it is not expected that spinal anesthesia would be effective.

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However, two patients have been benefited by sympathectomy after a trial with spinal anesthesia. Both were males under 8 years of age. One had a left lumbar ganglionectomy, the other, a left lumbar ganglionectomy, followed a year later because of continued episodes of ballooning-up, by a resection of the superior hypogastric plexus. Both boys are doing well at this writing, four years later, but a strict watch must be kept on their daily bowel habits, and occasionally an enema must be given. This care after operation is most important. It may, in itself, mislead us as to the effect of sympathectomy. If however, a similar and equally good type of régime has preceded the operation for years, it is fair to assume that the surgical procedure has benefited the patient. The same applies to the test of spinal anesthesia.

In an excellent study of anal achalasia and megacolon, Hurst<sup>3</sup> calls attention to several cases in which the disease existed for a number of years, in fact well into adult life, without untoward effect on the individual, except for constipation. He calls attention to the main object in the treatment which is to lessen the resistance offered by a closed anal sphincter to the passage of feces and gas. He suggests the use of an anal bougie which he left in place for half an hour, after a first morning attempt has been made to move the bowel. He states that often after removal of the dilator a movement follows. This simple method, along with enemata, in some cases given in the knee-chest position, and then, if without result after fair trial, resort to spinal anesthesia, is correct treatment in

all cases, and particularly in children, when the disease is first noticed.

Results in my hands, following sympathectomy of the superior hypogastric plexus and the inferior mesenteric branch, or, with lumbar sympathectomy alone in some cases, lead me to believe that the operation is of distinct value in cases of true Hirschsprung's disease when conservative measures fail. The point has been made that the anal achalasia is more likely to be due to underactivity of the parasympathetic supply, which militates against relaxation of the internal sphincter. The resulting imbalance is very likely only empirically brought nearer to normal by sympathectomy, yet the result should justify the means.

Colectomy should not be necessary if early relief is found by any of the means heretofore suggested. However, it is probably the only method of relieving a true dolichocolon.

The technique of the operation of superior hypogastric resection is too well known to be here described in detail. However, it should be remembered that many fine fibrils of nerve tissue may be overlooked if a careless resection is done, and that impulses may still be acting on the sphincters, enough it is quite possible, eventually to destroy any good effects which might have followed complete operation.

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# WATER AND CHEMICAL BALANCE IN SURGERY OF THE COLON

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THE average patient with a non-obstructive lesion of the colon requiring operation is not dehydrated or suffering from demineralization. He may be in a poor state of nutrition from lack of food intake, making him a favorable candidate for a deficiency in blood protein which predisposes to nutritional edema following operation. Dehydration and hypochloremia are not usually present in marked degree even in obstructive lesions of the colon as they frequently are in such lesions of the small intestine, since vomiting is rarely an important symptom of the former except in advanced cases.

In most of the cases requiring surgery of the colon the problem of dehydration begins when the patient is being prepared for operation. Newburgh, Wiley, and Lashmet<sup>1</sup> have found that normal adults eliminate approximately 1,000 to 1,500 c.c. of water daily as insensible fluid loss through the lungs and skin. Coller and Maddock<sup>2</sup> estimated the insensible loss of fluid of sick surgical patients as 2,000 c.c. per day with frequently as much as 2,500 c.c. per day when the patient has a fever. It is very evident that the insensible loss of water must be one of the first considerations in the water balance of all surgical patients.

The maintenance of water balance prior to operation is essential. Even if the patient is not obviously dehydrated the intake may be below normal or water may be lost in preoperative preparation, especially if active catharsis is used to empty the colon. Patients should be urged to drink at least 3,500 c.c. of water during the twenty-four hours preceding operation and should be permitted to have water up to three hours before the operation is scheduled. Too often

patients are deprived of water during the night preceding the operation and are sent to the operation with water deficiency.

If there is any reason why a patient cannot take water by mouth before operation or if there is doubt that sufficient water has been taken, 1,000 to 2,000 c.c. of 5 per cent dextrose in physiologic sodium chloride or Ringer's solution should be given by vein the morning of the operation.

When the operation is prolonged fluid should be administered during the operative procedure. Blood loss at operation must be added to the insensible loss of fluid. In some of the more extensive operations upon the colon and rectum, hemorrhage and shock are vital factors. A transfusion of 500 c.c. of blood is usually indicated either during or immediately after the operation. This may be given as citrated blood by the drip method.

The daily water need of the sick surgical patient has been quite accurately estimated by Coller and Maddock. Two liters should be supplied to replace water lost by vaporization, and 1,500 c.c. to produce a normal urinary output. The quantity needed for the average adult surgical patient is 3,500 c.c. per day plus the measured quantity of any abnormal fluid loss by vomiting, bleeding, wound drainage, drainage from intestinal or biliary fistulae and diarrhea. If the patient cannot take fluid by mouth it should be supplied parenterally by intravenous and subcutaneous injection. Five per cent dextrose in physiologic sodium chloride or Ringer's solution is usually used.

At this point it should be remembered that nature never planned that the human organism be watered and fed by vein and that certain dangers may be inherent in

such treatment. Experience and experimentation have taught that all solutions administered intravenously should be given slowly by the drip method or by carefully measured flow. A rate of 60 to 90 drops or 4 to 6 c.c. per minute has proved satisfactory. Gilligan, Altschule and Volk<sup>3</sup> found the blood volume increased after intravenous injection of the solutions mentioned above, which was more marked the more rapidly the injections were made. Since many patients requiring colon surgery are advanced in years and may have crippled cardiovascular systems, the slow administration of intravenous solutions is a very important safeguard. Other possible dangers are reactions with chills and fever, thrombosis at the site of injection in the vein with embolism and general edema resulting from the injudicious use of sodium chloride.

The quantity of sodium chloride necessary to maintain chloride balance has been estimated by Collier and his associates.<sup>4</sup> If 560 mg. of sodium chloride per 100 c.c. of plasma is taken as a standard normal, the chloride requirement may be estimated as follows: For each 100 mg. per cent that the plasma chlorides need to be raised to reach the normal 0.5 Gm. of sodium chloride per Kg. of body weight should be given. If whole blood chlorides are determined and 450 mg. of sodium chloride per 100 c.c. of blood is used as the standard normal, 0.6 Gm. of sodium chloride per Kg. should be used to raise the whole blood chlorides each necessary 100 mg. per cent to restore them to normal.

Intravenous injections are advised in broken doses rather than by continuous venoclysis as recommended by some authors. An injection of 2,000 c.c. may be given intravenously, beginning early in the forenoon and followed by a rest for a few hours at midday. A second injection of 1,500 c.c. intravenously or by hypodermoclysis may be given in the afternoon and early evening. The patient should not be disturbed by injections from 11 P.M. to 7 A.M. except in the initial treatment of

severe dehydration. Blood chemistry and urine studies are made at least every second day until normal intake of fluid and food by mouth are started.

There is danger of giving too much sodium chloride, especially to badly depleted patients deficient in protein. Excess of salt causes edema in the subcutaneous tissues and, according to Jones and Eaton,<sup>5</sup> may cause edema of the parenchymatous organs. The following report is a typical example of the excessive postoperative administration of sodium chloride:

CASE 1. R. G., age 49, was admitted to the University of Kansas Hospitals with a history of an acute attack of abdominal pain with vomiting. A large tender mass was found in the right abdomen which was diagnosed as an abscess of unknown origin. Pain, fever, and leucocytosis subsided in ten days and the patient was discharged to return later for observation. The mass did not entirely disappear and a barium enema showed a large defect in the ascending colon typical of carcinoma. He was readmitted to the hospital for operation. Before and after his last admission to the hospital he had had several chills.

Operation revealed a large mass in the ascending colon adherent to the pancreas, duodenum and gall-bladder. There were large metastatic nodules in the liver and mesentery. A lateral ileocolostomy was done.

Following the operation there was abdominal distention and vomiting. An indwelling nasal tube with continuous gastric suction was used for eight days. Daily injections of 2,000 c.c. of 5 per cent dextrose in Ringer's solution and 1,500 c.c. of Ringer's solution were given.

On the sixth postoperative day edema of the feet and ankles, flanks, and scrotum developed. The plasma protein was 5.21 Gm., globulin 2.56 Gm., and albumin 2.65 Gm. per 100 c.c. of blood. The plasma protein had dropped to the "critical level" and edema had developed. Too much sodium chloride had been given. The chloride solution was reduced to 500 c.c. per day and two blood transfusions of 500 c.c. each were given on successive days. Intravenous injection of 5 per cent dextrose was continued. In four days the edema had almost completely disappeared.

During this time the intestinal function had returned and protein food was started by

mouth in small quantities. The blood chemistry showed only a slight increase in the non-protein nitrogen and a slight decrease in the blood chlorides during the period of continuous gastric suction and development of edema. The patient recovered from the operation.

This patient had been ill for three weeks prior to the operation and had taken a limited protein diet. With a low blood protein, edema was rapidly produced by giving too much sodium chloride.

Another type of change in body chemistry is illustrated in Case II.

CASE II. P. H. F., age 66, was admitted to the University of Kansas Hospitals, August 20, 1938. He had noticed a movable mass in his right abdomen for one year. A diagnosis of

The urine and blood chemical findings in this case are in keeping with what has been described as a hepatorenal syndrome or what Rosenbaum<sup>6</sup> has called an entero-hepatorenal syndrome. If this explanation of the changes in blood chemistry is accepted the conclusion is drawn that the operative procedure on the colon resulted in pathologic changes in both liver and kidneys. The increase in the blood sugar shown in the table during the days showing increase in the non-protein nitrogen is probably due to the increased intake of dextrose during that period to supply the liver with glycogen and produce diuresis. During these same postoperative days there was a decrease in the total cholesterol and in the percentage of esters. It is sug-

TABLE I  
CHANGES IN BLOOD CHEMISTRY OF CASE II

Day after Operation	Non-protein Nitrogen, Mg. per 100 C.c.	Creatinine, Mg. per 100 C.c.	Sugar, Mg. per 100 C.c.	Whole Blood Chlorides, Mg. per 100 C.c.	Cholesterol, Mg. per 100 C.c.		
					Total	Esters	Per Cent Esters
0	35	1.1	81	440			
3	27	1.4	90	450			
7	111	2.5	89	450	198	116	58
8	150	2.5	95	370			
9	128	2.3	115	470			
10	154	3.2	113	380	185	91	49
11	110	2.6	133	310	161	63	39
12	107	2.0	118	300			
13	100	2.6	118	320	157	51	39
17	45	1.2	86	425	107	68	63
21	41	1.2	83	510			
25	30	1.2	83	460	138	83	60

carcinoma of the cecum was made. The cecum, ascending colon, and a portion of the transverse colon were resected by the Lahey technique. Following the operation he developed a rise in the blood non-protein nitrogen, creatinine, and sugar, and a fall in the chlorides and cholesterol. These changes are shown in Table I. The urine was normal on admission. From the tenth to the forty-third postoperative day at various times the urine showed a specific gravity of 1.010 to 1.019, finely granular and coarsely granular casts, red blood cells and pus cells. The twenty-four hour output of urine was never below 600 c.c.

gested that the changes in cholesterol may have been a result of liver damage.

The oxygen need in patients suffering from dehydration and decrease in blood electrolytes is as yet but poorly understood. Fine<sup>7</sup> has shown that the administration of high percentages of oxygen increases gas absorption from a distended intestine. Davis,<sup>8</sup> in his studies in water balance, has observed a marked lowering of the basal metabolic rate in certain nutritional states with a very definite increase in oxygen consumption after the

injection of 0.9 per cent sodium chloride and 5 per cent glucose solution in dehydrated animals. It has also been suggested that the permeability of the capillaries is increased in starvation due to a lack of oxygen supply to the tissues.<sup>9</sup> Following operations upon the intestinal tract the administration of water and electrolytes aids in maintaining metabolic balance. Oxygen therapy is indicated in severe toxic conditions when there is post-operative abdominal distention, a change in blood chemistry, and lung or heart complications. Oxygen should be administered early and should not be left as a last resort measure.

#### SUMMARY

Following operations upon the colon resulting in disturbed function of the alimentary tract, dehydration and changes in body chemistry may rapidly become factors of prime importance. Dehydration usually plays the most important rôle in the disturbance of metabolism in general. As a result of dehydration there develops impairment of circulation and oxygenation, impairment of kidney function, retention of metabolic waste products, and disturbance of the heat regulating mechanism. Acid-base imbalance develops when there are extreme changes in body chemistry. Although the clinical terms "alkalosis" and "acidosis" are frequently loosely used and poorly understood, they must be considered in the changes of chemical balance associated with surgical diseases of the gastrointestinal tract.

The treatment of dehydration alone is relatively simple, but in surgical conditions dehydration is so much involved with

changes in the body chemistry and metabolism that therapy becomes complicated. The judicious administration of water and sodium chloride tends to restore body chemistry to normal but does not entirely fulfill all therapeutic requirements of disturbed metabolism and pathologic changes that may result from water, chemical, and food deficiency.

In a study of water and chemical balance from the surgical standpoint the loss of water and chlorides are not alone to be considered, but a broad view must be taken of changes in body chemistry and metabolism which may result not only from the disease but from the surgery instituted to cure or alleviate the disease.

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# REGIONAL ILEITIS\*

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IN a recent article by E. C. Cutler of Boston, the author indicates that in "cicatrizizing enteritis surgery is not a cure, that recurrence following radical resection is frequent, and that patients may recover spontaneously." He expresses the hope that "the patient will be retained in the hands of the family physician, thus avoiding the sufferings which accompany surgical therapy." These remarks emanating from an eminent surgeon are all the more significant and call for due consideration and an answer without bias or prejudice.

The questions which are raised by this query are:

1. Is regional ileitis or cicatrizizing enteritis capable of spontaneous recovery?
2. Is the disease successfully treated by medical means?
3. Is the surgical approach accompanied by danger and suffering?
4. Are recurrences after resection common?

I prefer to give only my own experiences covering 130 cases of regional ileitis, by which comprehensive title are included terminal ileitis, more diffuse regional ileitis, and finally high ileitis and jejunitis or, as the latter is sometimes named, cicatrizizing enteritis. This large number of cases—large for a disease only recently recognized as of clinical importance—includes a majority of cases treated surgically and a minority (about forty-five cases) treated by conservative or medical means, or postponing operation.

## I. IS ILEITIS OR ENTERITIS CAPABLE OF SPONTANEOUS RECOVERY?

Yes, when one speaks of acute ileitis, that type of terminal ileitis which simulates acute appendicitis, an "acute abdomen"

characterized by lower right quadrant pain, fever, rigidity, leucocytosis and a suggestion of a mass. The diarrhea is usually overlooked. In most of these cases the appendix is removed (a superfluous gesture) and the fulminating ileitis is returned to the abdomen untouched. A majority of such cases will resolve, possibly never to be heard from again (eight out of eleven cases).

However, complete resolution may not occur, for some patients eventually develop the full picture of a chronic regional ileitis with mass, fistulae, and even obstruction. One such typical case was observed for a year and one-half. The onset was subacute and moderate, with low-grade fever and abdominal pain, but with diarrhea. The rule not to regard any case with diarrhea as acute appendicitis was an accurate gauge in this instance. The x-ray examination was negative, no deformity of the ileum being recognizable. Operation was therefore denied and a period of observation and medical (?) treatment prescribed. Six months later, symptoms persisting, the patient was again subjected to study. A barium enema now revealed a slight fuzziness and an indistinct outline to the terminal ileum. Another period of observation over a full year followed, with intermittent bouts of diarrhea and slight fever. A third radiogram now evidenced a typical "string sign" deformity of the terminal ileum. At operation, 18 inches of terminal ileitis was successfully resected; the patient has remained well to date (two years). This case is not an unusual one and is characteristic of the common course of the disease.

That the fulminating acute ileitis can and may resolve is gladly conceded, but that such spontaneous recovery is a peremptory

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rule is doubtful, even after reperusal of Koster's paper<sup>1</sup> claiming resolution in six such instances. It is my feeling that most of the acute cases of ileitis will eventually be found among the chronic cases with cicatrizing lumen, mass formation and obstruction, though it may take years before this indolent granulomatous malady presents itself with obvious and manifest symptoms.<sup>1</sup>

There is pathologic evidence of a healing tendency in regional ileitis, that is, cicatrization takes place, scar tissue is formed and contracts. The evidence for such a healing process lies in the cases of subacute intestinal obstruction in which the lumen of the ileum is so diminished by scar tissue contraction that obstruction results. In my own experience, such attempt at healing of a granulomatous process is not true healing, but represents only the throwing out of cicatricial fibrous tissue that accompanies the active stage of all chronic inflammatory processes. Such a contracture of the lumen of the intestine does not represent a last-stage healing of a previously active lesion; it goes always hand in hand with an actively progressing lesion at the more proximal areas of the process. At the oldest site there may be seen scar tissue with cicatrization; at the more recent areas active extension. This, therefore, cannot honestly be interpreted to mean that ileitis is capable of spontaneous healing with restitution to normal tissue and normal functional capacity.

And even if such healing were conceivably possible, if the healing of the granulomatous tissue took place in such a manner that health were restored but functional integrity were impaired or destroyed by the narrowed scarred lumen of the intestine leading to obstruction, then such spontaneous healing by conservative medical means would defeat its own purpose.

This may be construed as an overstatement of the case, as a morbid or pessimistic envisionment of the problem. Perhaps, it may be argued, chronic granulomatous

ileitis is actually capable of complete healing with a return to normal health and integrity of the bowel, without scarring or cicatrization. Such an optimum happening I have never seen; once a lesion is established by radiographic evidence, the deformity of the bowel remains whether the clinical symptoms improve or do not improve. The defect stays until surgically resected. Like all other chronic diseases ileitis may have long periods of remission and apparent quiescence, but unless radiographically one can demonstrate the disappearance of the lesion in the intestine, healing cannot be said to have occurred. True, with short-circuiting operations, subsequent resection will often show distinct scarring of the involved area with replacement of the lost mucous membrane and a complete quiescence of the lesion. This is veritably "healed ileitis," but by no stretch of imagination can a short-circuiting operation be construed to be synonymous with conservative medical means.

## 2. IS CHRONIC ILEITIS TO BE SUCCESSFULLY TREATED BY MEDICAL MEANS?

What medication can be expected to be successful in a disease the etiology of which is still an enigma? Most patients with ileitis present themselves with a history of several months or years, many with an intermittent history covering five, ten, or more years. These cases have all been "treated medically," usually with intestinal sedatives, opiates, non-roughage diet, light therapy, etc. In no way does the inexorable course of the malady seem changed or ameliorated.

The history of such patients is usually a progressive one of increasing pain and diarrhea, slow but uninterrupted loss of weight and efficiency, and advancing anemia. In many cases where operation is denied, successive x-ray examinations will show evidences of new extensions to a higher level of the ileum, evidences which are clear and incontrovertible when the successive series of radiographic films are placed side by side.



Is it the contention of the conservative bloc that these progressive cases represent only the failures of spontaneous recovery and that another larger group having resolved, remain outside the field of observation as cured cases? We know that healing in ileitis is associated with cicatrization (hence the title!), narrowing of the lumen, and frequently with partial obstruction. One would expect under such circumstances to find in mass autopsy statistics, some case or cases of healed and scarred ileitis. Not so, however; I know of no incidental or accidental finding of a healed case of ileitis, either in published reports or in my personal experience at necropsy observations.

Two patients with high ileojejunitis have been under my observation for several years. Because of the extent of the lesion and the widespread involvement of most of the small intestine, mass surgical resection was disallowed and treatment was perforce restricted to medical means. "Medical means" is understood to consist of a non-roughage but abundant diet, vitamin replacement therapy, rest and sunlight. Occasionally nonspecific protein therapy in the form of typhoid vaccine intravenously applied has been utilized. In both of these cases some gain in weight has been observed and some general improvement. However, successive radiographic studies not only fail to show a disappearance of the lesion or a change for the better in the contour of the diseased loops of intestine, but show a continued shrinkage in the transverse diameter of the gut and distinct evidences of cicatrization.

In the last few months I have had another illuminating experience. A young man 23 years of age has had a clear-cut history of ileitis for one year. He had a continuous course of slight fever, cramps, abdominal pain and diarrhea. Three months ago his radiographic studies showed a typical involvement of the last 8 to 10 inches of terminal ileum, with a fistulous tract leading upward to the transverse

colon. The patient declined operation and insisted upon a trial of medical therapy. To this I was very glad to accede just because of the question involved as to the final efficacy or inefficacy of such a line of attack.

Having convinced myself for years that brilliant results could and are being achieved in the treatment of ulcerative colitis by typhoid vaccine used as a non-specific protein agent, I found the terms of this experiment very appealing. Therefore the patient was hospitalized, placed on a non-roughage diet, received light therapy, and every third day received intravenously a dose of typhoid vaccine, sufficient to induce a chill and rise of temperature to approximately 102° to 103°F. In ulcerative colitis this method of therapy usually does brilliantly, causing a cessation of diarrhea and pain and rapid change for the better; in addition, relapses can be avoided by continuing the treatment prophylactically with injections at longer and longer intervals.

In the case of this young man with ileitis, the same line of therapy seemed to be associated with success. The diarrhea and cramps ceased, he was more comfortable, became afebrile and gained appetite and weight while in the hospital under close observation. At the end of the probationary period and after the symptoms had ceased, he was again subjected to x-ray study. No material or obvious change had occurred in the lesion as compared with the plates taken by the same technique before the institution of therapy. Within three weeks of discharge from observation he was again seized with pain and diarrhea. A recheck of the condition at the Mayo Clinic revealed that not only was the ileitis not cured, but, on the contrary, it showed extension of the lesion into new and higher ileal territory. At operation, three months after institution of medical therapy, an extensive, active, regional ileitis was found with four fistulae leading to various segments of the colon and with distinct involvement of ascending and transverse colon. A radical

and complete resection was now out of the question.

Of course, the failure of conservative therapy in this case (and others) and the attempt to draw conclusions therefrom, may properly be criticized on several grounds. One may object on the score that experiences were insufficient in number, not sufficiently prolonged; that the means of therapy were indiscreetly chosen, or that a black ignorance pervades the field. True, failures to cure, to date, do not exclude the possibility of some future successful plan, nor does one person's ignorance necessarily throw a blight over the better results in more sophisticated hands. One lives to learn, one is willing to sit at the feet of the wise and call him master who will achieve a successful form of conservative therapy for regional ileitis.

### 3. IS THE SURGICAL APPROACH ACCOMPANIED BY DANGER AND SUFFERING?

Yes, like all other abdominal surgery, the result is pain and a risk of life. Both short-circuiting operations (when accompanied by transection of the ileum *above* the lesion) and resections are attended by a considerable mortality, approximately 10 per cent in the palliative procedure, and 15 per cent in the more radical enterprise. But there are compensatory advantages to the greater risk in the latter type of operation. Only half of the short-circuiting operations are attended with success, the other half requiring later resections with a necessarily greater risk. The radical resections are more satisfactory, in at least 90 per cent returning a dividend of perfect health and function. A severe disease must call for severe measures, and regional ileitis is a serious malady. Anyone who has seen the end results of neglected cases, with mass formation, multiple fistulous tracts to the abdominal wall, perineum and adherent hollow viscera, or who has been forced to operate in the presence of subacute intestinal obstruction will have some respect for the intra-abdominal havoc caused by the

relentless progress of this granulomatous lesion.

The mortality which accompanies all surgical procedures is, as of this date, magnified by the fact that we are still seeing, in this early first decade of our experience, large numbers of advanced, complicated, and unrecognized cases. The present heavy mortality is in large part due to low-grade perforations, associated local peritonitis, and long-range fistulous tracts, all of which represent late and disastrous complications of what was, in its initial phases, a purely localized and relatively simple pathologic process. Had surgical interference not been denied in the earlier stages, the complicated and dangerous delayed resections would not have been necessitated. To perform a partial gastric resection for an uncomplicated peptic ulcer means a mortality of, let us say 5 to 7, or even 9 per cent, depending upon whose surgical hands are invoked; to perform a resection in the presence of a gastrojejunal ulcer or a gastrojejunocolic fistula means to run up the surgical mortality to 15 or 25 per cent.

If, in the next few years, the profession learns how to recognize ileitis and identify the early phases of the process (a diagnosis which is relatively simple and entirely possible), and if the profession, having cleared up the hang-over of neglected and complicated cases, will meet the newly recognized cases with direct approach and surgical attack, the mortality should proportionately fall to within reasonable limits and should show a most satisfactory situation, both as regards minimal risk and maximal end result.

If there be dissension in the ranks, if there be a failure of minds to agree upon a straightforward radical attack, if there be subversive elements who preach caution when delay is dangerous, the surgical situation will remain less satisfactory than it should be. Clean up the old cases, approach the new cases without doubt or hesitation and the eventual situation should be increasingly satisfactory to both conserva-

tive and liberally-minded members of the profession.

#### 4. ARE RECURRENCES AFTER RESECTION COMMON?

Unfortunately, as the situation now stands, the fact cannot be denied that even in the best of hands recurrences do occur. Whether 7.7 per cent represents the correct figure for recurrence or a slightly higher rate is actually present, is difficult to state at this early period. Suffice it to say that even the minimal rate of 7.7 per cent is serious and assumes a magnitude which defies an attempt to ignore it or to sidestep the issue.

To obviate this situation requires two measures. First, the initial exploratory phase of the operation must be extended to include a most careful search for skip lesions and areas of higher involvement. The resection or the short-circuiting procedure must exclude all infected tissue. The question that arises is: Can the fingers of the exploring surgeon always recognize by tactile sense where the lesion ceases and what is its absolute proximal limit of invasion? Or, can he by observation of the enlarged succulent lymph nodes reliably determine the extent of the involvement? From the number of recurrences I have seen in even the most competent hands, it would appear that the reliable determination of the upper limit of disease is not an easy one, that there may be sub-threshold minimal involvement of mucosa (or lymphatics) defying the senses of touch and sight. If this be the case, then resection or palliative procedure should in the future allow much more safe area, and to be absolutely certain, should be performed at a greater distance from the obvious line of proximal disease. Let no one worry about intestinal function, or postoperative diarrhea, or disturbances of absorption of nutrition and vitamin balance after a more

radical resection. The 20 or more feet of small intestine and the 8 or more feet of colon are ample safeguards that denounce penury when determining the limits of resection. Actually we have now so many cases with subtotal colectomies for regional colitis, and so many high intestinal resections without any degree of diarrhea that interferes with perfect health and function, that one should not only call for earlier surgery, but also for bigger and more extensive resections.

It may seem that emanating from one who is supposed to represent the more conservative element of the medical profession, these personal opinions transcend even those of radical surgical enthusiasts on the subject of the treatment of ileitis. I would be willing to go even a step further. On four different occasions I have had the experience of making a clinical diagnosis of ileitis, only to have this opinion reversed by the radiographic report denying the presence of a lesion in the terminal ileum. Nor could I really find fault with the interpretation of the x-ray plates, though in possession of all the clinical facts, my eye could see faint fuzziness and indistinctness of mucosal pattern in the terminal ileum that no impartial radiographer could safely admit. These four patients came later to operation and all represented true cases of terminal or regional ileitis. Looking backward, one feels entitled to a righteous regret that the exploratory laparotomy had not been insisted upon at the earliest date of clinical recognition. Herein lies a strong argument for early operation, for higher resections or short-circuitings, and herein probably lies the solution to the regrettable problem of recurrences.

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# THE SURGICAL MANAGEMENT OF CHRONIC INTRACTABLE ULCERATIVE COLITIS

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IT has been only within the last ten years that radical surgical measures have been employed to any extent in the cure of chronic ulcerative colitis. We all know that for many years appendicostomy, cecostomy, and ileostomy have been considered curative procedures, but in the light of our present knowledge these are thought to be of little benefit. Previously, the entire diseased large bowel was rarely removed, and only in one or two instances by any individual surgeon. Howard Lilienthal<sup>1</sup> of New York, in 1899, was one of the first American surgeons deliberately to perform colectomy for what was previously diagnosed a chronic intractable case of this disease in a young woman 25 years of age. The outcome was successful and the patient is still alive.

Failure of medical measures when this disease has reached the intractable stage has led to surgical intervention in an increasing number of cases. No clinician of wide experience with this disease at the present time is willing to accept the term "cure." It is true that not infrequently conservative measures have been followed by temporary improvement, but unfortunately the improvement has not been sustained. It is unlikely that after any given period of freedom from activity the disease will not exhibit a recrudescence. Clinicians generally are now admitting that many patients have been lost in the past because radical surgical measures were denied them.

## INDICATIONS FOR SURGERY

The indications for surgery can be based fairly accurately on the clinical picture: (1) the effects of toxemia and sepsis; (2) local symptoms referable to the bowel and by the

use of roentgenograms; (3) fistulae, sinuses, hemorrhages and perforations, either sub-acute or chronic, and strictures; and (4) where there exists a diffuse polyposis with or without malignancy.

During the past three years, we have had what we consider an unusual opportunity to study intensively many patients suffering from ulcerative colitis. A special thoroughly equipped laboratory was established for the sole purpose of investigating this and allied diseases. So far, many of these patients have proved temporarily amenable to medical treatment. Some have become surgical responsibilities. One hundred and sixty patients with this disease have been treated in our institution. Twenty-nine have been subjected to surgery, and it is from this experience that certain deductions have been obtained which we believe worthy of presentation. The following operations have been performed on twenty-nine patients:

Ileostomy.....	21
Ileosigmoidostomy.....	3
Partial colectomy with low transverse colostomy.....	2
Partial colectomy with removal of rectum.....	2
Colectomy.....	11
Colectomy with removal of the rectum	3

There are four types of the disease: (1) mild cases, at least temporarily arrested and perhaps cured by medical management alone; (2) acute fulminating, frequently fatal; (3) chronic continuous; and (4) chronic with remissions. Confusion exists in the minds of many observers as to when the stage of intractability has been reached, and there has been a diversification of opinion up to the present as to the proper time for surgical intervention. These two problems appear often difficult of solution,

yet must be faced and solved if successful outcome is to be expected. It is considered necessary that all patients suffering from this disease should be meticulously studied, and some over a prolonged period of time. In the acute fulminating forms, prolonged study wastes time, increasing morbidity and mortality. Needless to say, vitamin and other deficiency states should be rectified and all foci of infection eradicated. Considerable reliability can be placed on comprehensive roentgenograms, and particularly on proctoscopic examinations (for 90 per cent originate in the rectum).

The x-rays show characteristic shortening of the entire colon, narrowing of the lumen, mucosal destruction and absence of haustral markings. The normal angulations at the flexures tend to approximate right angles. The barium enema demonstrates a rapidly filling colon with hyperirritability of the involved segments. Such a picture is a clear indication of the removal of the diseased colon.

#### PREOPERATIVE PREPARATION

The preoperative preparation of these patients is of the utmost importance. In fact, it is of more importance than in almost any group of surgical patients that we encounter. Thin, emaciated, dehydrated, anemic, septic and forlorn, they present a pitiful picture. For the most part, most of these individuals that come to surgery have been carefully investigated by the clinicians and their deficiencies corrected. Even so, we consider essential intravenous glucose and saline twice daily, transfusions if indicated, low residue diet, gentle cleansing colonic irrigations with warm saline, and for two days prior to operation, lead and opium pills and paregoric in order to shrink the bowel, thus simplifying technical maneuvers.

#### ANESTHESIA

These patients seem to tolerate avertin, gas, oxygen, and ether. We have found novocaine, preferably pontocaine and nupercaine, as spinal anesthetics eminently

fitting for prolonged continuous action, thus affording relaxation at the second stage when the colon is removed.

#### THE SELECTION OF OPERATIVE PROCEDURE

We feel justified in emphatically stating that whatever procedure is chosen, and no matter how many stages are found necessary, all of the diseased bowel should be removed, otherwise a cure cannot be hoped for. Due to the markedly debilitated condition of these individuals, two, three, and even four stages may make for added safety.

Ileostomy is the first stage in 75 per cent of the cases. It is important that the terminal ileum be divided in an area which is not involved, whether it be 6 inches from the ileocecal valve or 3 feet from the ileocecal valve. The ileostomy should be placed on the anterior abdominal wall at a point where it can be cared for easily. The proximal loop should be drawn well out, 3 or 4 inches if possible, and not sutured in any manner to the anterior abdominal wall, for no matter how carefully placed the sutures are through the serosal surface, in coughing or straining after operation, leaks may occur and annoying fistulous openings result. We have found that ileostomies placed too close to the midline predispose to intestinal obstruction, on account of loops of small intestine encircling it. Therefore, a McBurney incision is chosen and the mesentery sutured to the lateral peritoneal reflection to prevent loops of small bowel from being caught and becoming obstructed. We believe the practice of exploring the abdomen at the time of the performance of ileostomy a pernicious one. It is frequently safer to bring out the distal end as a mucous fistula rather than to turn it in and drop it back, as was originally advocated by Rankin. Ileostomy is accompanied by a relatively high mortality, due, I believe, principally to the fact that these patients are brought to surgery too late. It is an undeniable fact that ileostomy alone has, in a few authentic cases, proved not merely palliative but curative.

Ileosigmoidostomy has been used as a first stage procedure in a small group of individuals where the rectum had been previously determined free of the disease. When the left colon and rectum are alone involved and it has been accurately proved that the process has become stationary, transverse colostomy is justified as a first stage procedure. Care should be taken that the colostomy in the transverse colon is placed in a healthy segment of the bowel. Over 90 per cent of the patients in our series, following ileostomy, have shown a tremendous gain in weight, due to diversion of the fecal stream. Four to six months is usually allowed before the second stage of subtotal colectomy is contemplated. We have performed subtotal colectomy eleven times, with one death. A most striking feature of this seemingly extensive operation has been the mildness of the postoperative reaction, as well as the fact that all of our wounds have healed per primam.

The second stage of subtotal colectomy we have carried out through a long left paramedian incision. There are two points during this maneuver which have seemed somewhat difficult: (1) starting the mobilization of the distal terminal ileum, cecum, and ascending, and (2) the division of the splenophrenocolic ligament. Careful hemostasis must be effected, and warm moist pads used to protect the exposed coils of intestine, diminishing the chance of rapid fall in blood pressure. We have made it a practice to separate the omentum from the transverse colon for the reason that it simplifies the removal of the colon and preserves the omentum for the purpose of covering raw areas. In mobilizing the right colon, it is well to identify the right ureter, particularly in its lower half, and the third portion of the duodenum higher up, which may be easily injured if care is not taken in thoroughly exposing it. A fall of blood pressure not infrequently follows the division of the middle colic artery, and it is at this stage where we have been forced to immediately resort to transfusion. As has been stated, the most difficult part of the

entire procedure is adequate exposure and division of the splenophrenocolic ligament. When this has been accomplished, the left colon is easily mobilized, and we have had but little difficulty in securely closing the stump of the sigmoid colon with several layers of interrupted silk sutures. If the bowel at this level is friable, it is safer to bring this out as a mucous fistula instead of attempting closure. We have made a practice at this second stage of peritonealizing all raw surfaces. It does prolong to some extent the operation, but we feel it also minimizes the chance for the formation of adhesions.

The third stage is carried out by the combined abdominoperineal resection some four to six months later, when there has usually been an appreciable gain in weight and the patient has been rehabilitated. After ileostomy, after subtotal colectomy, and after the third stage of combined abdominoperineal resection of the rectum, transfusion has proved beneficial. In the poor risk patient, four stages are of necessity employed; the second stage may stop with removal of the right colon and a part of the transverse colon, the third stage consisting of removal of the remainder of the transverse colon, splenic flexure, and descending colon.

#### COMPLICATIONS

The most frequent complication following the operations for the cure of this disease is peritonitis. Perforation of the colon has occurred, even though diversion of the fecal stream has been accomplished with ileostomy. Where the disease is far advanced, strictures and massive hemorrhages occur, even though the fecal current has been sidetracked. Ileus is not an infrequent complication.

Of twenty-nine patients sent to surgery, five died, giving an operative mortality of 17.2 per cent.

#### CONCLUSIONS

1. Surgery should be delayed until two factors have been adequately evaluated:

(1) the response to conservative treatment, and (2) the extent and distribution of permanent damage to the colon.

2. As yet, it is difficult to define the criteria for determining operability.

3. Operative maneuvers are based upon and determined by the situation of permanent damage to the colon.

4. Ileostomy has been in the past accompanied by a high mortality rate, due to the fact that the clinicians have been reluctant to subject these patients to surgery until in the late stages, and also to the fact that they have become rapidly dehydrated due to loss of fluids and chlorides through the ileostomy.

5. Staged procedures are carefully planned, adequate time elapsing between the stages to insure satisfactory rehabilitation.

6. Of 160 patients studied, twenty-nine were subjected to surgery with five deaths, or a mortality of 17.2 per cent.

7. Following removal of the colon and rectum, the ileal stoma takes on the characteristics of the rectal pouch. The stools become more solid and are better formed.

8. These patients gained from 40 to 50 pounds after removal of the diseased colon.

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THE simplest and in most cases the best method of treatment of a benign rectal stricture is dilatation under anesthesia with or without intra-luminal incision.

# GASTROJEJUNAL ÚLCER: A STUDY OF 155 CASES

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THERE is probably no surgical subject that has occasioned as much thought, research and controversy or as voluminous a literature as has gastroduodenal ulceration and its complications. In spite of the tremendous amount of work which has been done on the subject, there are still many problems which are as yet not satisfactorily solved, and of these, gastrojejunal ulceration is one of the most important. Fortunately, gastrojejunal ulceration is not a frequent complication of the surgical treatment of gastroduodenal ulcerative disease, but it is a complication of major importance.

## ETIOLOGY

The cause of gastrojejunal ulceration is not definitely known. It has been suggested that the condition might be due to errors in surgical technique, to unabsorbed suture material used in the anastomosis or to pressure of the clamps used. It is now generally agreed, however, that these factors are probably not of great importance and that gastrojejunal ulceration is probably due to the same factor that produced the original gastric or duodenal ulceration, namely, a lowered tissue resistance to gastric secretion. The development of gastrojejunal ulceration indicates that the chemical changes in the acidity of the gastric contents and the changes in motility that are the result of the gastrojejunal anastomosis have failed to control the ulcer-forming tendencies.

Ochsner and his associates have suggested that according to our present knowledge the most important factors in the causation and persistence of peptic ulcer are: (1) an inherited constitutional predisposition to form ulcer, that is, an ulcer diathesis; (2) a tissue susceptibility to

ulceration; and (3) an increased acidity of the gastric contents. There are undoubtedly other factors which may contribute to the development of ulcers, but these outlined by Ochsner are probably the most important. Of all factors, the ones that are most amenable to control are increased gastric acidity, pylorospasm and decreased emptying time of the stomach. The medical therapy of ulcer attempts to control acidity by frequent feedings and alkalis. Surgically, acidity is controlled either by gastroenterostomy or partial gastrectomy. Both operations bring about dilution and neutralization of gastric acids with alkaline duodenal, pancreatic and biliary secretions, and the latter results in removal of a portion of the acid-stimulating and acid-secreting portion of the stomach. Relief of pylorospasms and increase of the emptying time of the stomach occur after partial gastrectomy, gastroenterostomy and pyloroplasty. However, tissue susceptibility to recurring ulceration is a factor which at present is difficult to control. It is unfortunate that there is no method of determining predisposition or tissue susceptibility to ulceration. If one was able to measure this factor one would be able to determine in which cases of ulcer radical methods of treatment, such as gastric resection, would be required and in which cases the patients could be satisfactorily treated by more conservative methods, such as gastroenterostomy, pyloroplasty and gastroduodenostomy.

## INCIDENCE

It is generally agreed that gastrojejunal ulceration is essentially a complication of the surgical treatment of duodenal ulcer. However, the condition can develop after any surgical anastomosis of the stomach



to the jejunum. Although gastrojejunal ulceration may develop subsequent to gastroenterostomy for gastric ulcer, it does so rarely. Seldom does it develop after extensive partial gastrectomy and more seldom still does it develop after palliative gastroenterostomy for inoperable carcinoma of the stomach.

It has been our experience at the Mayo Clinic that gastrojejunal ulceration has rarely complicated surgical treatment of gastric ulcers. In 1930, Balfour<sup>2</sup> reported that gastrojejunal ulceration did not occur in any of a series of 100 cases of gastric ulcer in which the patients were treated solely by gastroenterostomy. In a review of a recent series of 252 cases of gastric ulcer in which various surgical procedures were employed, we found that gastrojejunal ulcer did not develop subsequently in a single case. On the other hand, Wright<sup>34</sup> in England has reported that gastrojejunal ulceration occurred in 10.45 per cent of 884 cases of gastric ulcer in which gastroenterostomy was performed. We find it difficult to account for this incidence since such a high incidence has not been reported by any other investigators so far as we know.

There is also a rather marked discrepancy in the incidence of gastrojejunal ulceration after gastroenterostomy for duodenal ulcer, as reported by various investigators. Balfour,<sup>2</sup> in 1930, reported an incidence of 3.2 per cent in a series of 500 cases in which duodenal ulcer was treated by gastroenterostomy. Heuer, in 1935, reported an incidence of 3 per cent in 1,559 cases in which operation was performed by seventeen different surgeons. In an unselected series of 744 cases of duodenal ulcer collected and reported by Luff, in which the operation was performed by many surgeons (members of the British Medical Association), the incidence of gastrojejunal ulcer was 2.8 per cent. Walton has estimated the incidence at 3 to 4 per cent, Kelly at 2 to 5 per cent, and St. John at about 7 per cent. On the other hand, Wright<sup>34</sup> found an incidence of 8.49 per cent in 2,734 cases of duodenal ulcer in

which gastroenterostomy was performed. Lahey estimated the incidence at 15 per cent, Ogilvie<sup>23</sup> at 20 per cent, Lewisohn, at 34 per cent and von Haberer, Finsterer,<sup>7</sup> Berg and Strauss at from 8 to 30 per cent. Lorenz, who, with Schur, was one of the first, if not the first, to advocate gastroenterostomy as a routine method of treatment of duodenal ulcer, reported the incidence of gastrojejunal ulcer to be 10 per cent in his cases in which this operation was performed for duodenal ulcer.

There is almost as great a discrepancy in the various estimates of the incidence of gastrojejunal ulceration after partial gastrectomy. Apparently, gastrojejunal ulceration rarely occurs after partial gastrectomy is performed for gastric ulcer. In the experience of one of us (Walters) it has not been observed in cases in which the gastric ulcer was benign and two-thirds or more of the stomach was removed. All writers agree, however, that there is a definite incidence of gastrojejunal ulceration after partial gastrectomy for duodenal ulcer. In 1928, Balfour<sup>1</sup> reported a series of twenty-eight cases in which recurrent ulceration occurred after partial gastrectomy, and in the same year Hurst and Stewart collected more than eighty similar cases. Starlinger reported recurrent ulceration in 0.5 per cent of a collected series of 2,500 cases in which antecolic resection was performed for duodenal ulcer and in 0.6 per cent of 14,200 cases in which postcolic resection was performed. On the other hand, Sawkoff in a recent review of Russian literature reported a series of 126 cases in which gastrojejunal ulceration occurred after primary partial gastric resection was performed for duodenal ulcer, an incidence of 4.32 per cent, a figure comparable to the usually accepted incidence of gastrojejunal ulceration after gastroenterostomy. Wright<sup>35</sup> has reported that the incidence of gastrojejunal ulceration was 2.75 per cent in a series of seventy-seven cases in which a posterior Polya resection was performed for duodenal ulcer. Statistics from one of the large hospitals in the eastern part

of the United States showed that gastrojejunal ulceration occurred in 3.1 per cent of cases of duodenal ulcer in which a Polya resection was performed.

Probably at least a part of the variations of these estimates is due to the so-called geomedical variation of types of lesions and by the part played by racial factors in these differences. This factor has been commented on by Snell and one of us (Walters), and by von Haberer and Schittenhelm.<sup>9</sup> Another factor of importance is the amount of stomach removed by the resection. There is no doubt that some recurrences are due to the failure to perform a sufficiently extensive resection. Finsterer<sup>8</sup> said that in most cases the ulceration is due to this factor. Most authorities agree that about two-thirds of the stomach should be resected. Others feel that removal of three-fourths or four-fifths of the stomach is necessary.

A third factor is the postoperative regimen. Some authorities feel that if an extensive resection is performed there is no necessity for instituting any type of postoperative dietary regimen. Others feel that failure to emphasize this factor is responsible for some recurrences. In a recent visit to some of the surgical clinics in Belgium, one of us (Walters) was impressed with the very extensive partial gastrectomy performed for duodenal ulcer; approximately four-fifths of the stomach was removed routinely. Recent literature indicates that partial gastrectomy for duodenal ulcer is more productive of jejunal ulceration than was formerly suspected. Advocates of conservative operation have called attention to this fact and have pointed out that the possibility of recurrence of ulceration after gastric resection must be carefully considered before subjecting a patient to the added risks of partial gastrectomy. Practically all writers agree that partial gastrectomy is much less productive of jejunal ulcer than is gastroenterostomy, but some still doubt if the advantages of resection are worth the higher risk, especially since resection does not leave the

avenues of surgical retreat, in case of recurrent ulceration, that are available if gastroenterostomy has been performed. Furthermore, in a definite percentage of cases in which extensive partial gastrectomy has been performed, although the patient may not have a recurring ulcer, gastritis in the upper part of the stomach may continue to exist and cause some dyspeptic symptoms (Fig. 1), and in another group of cases vagotonic symptoms, such as sweating and faintness, which occur after the ingestion of food and cause the patient to spend a short time in the recumbent position, may be a source of annoyance.

The following case is interesting in view of the finding of gastritis at necropsy.

A man, aged 51 years, first came to the clinic on April 25, 1938. He stated that in 1932 he had been operated on for closure of a perforating duodenal ulcer. A gastroenterostomy had been performed in 1930 and six months later symptoms of ulcer had recurred. Roentgenologic examination did not reveal the gastroenteric stoma but it did disclose a duodenal ulcer with a deep crater. The patient also had angina pectoris. On May 2, 1938 a gastrojejunal and a duodenal ulcer were removed and a partial gastrectomy was performed. The patient made an excellent recovery and was well until February 24, 1939, when he began to have intermittent chills and fever. The patient returned to the clinic on March 10, 1939, at which time a diagnosis of meningitis was made. In spite of all medication the patient died on April 14, 1939. Necropsy revealed acute cerebrospinal meningitis, bronchopneumonia and gastritis in the remaining portion of the stomach (upper third following posterior Polya resection).

It is difficult to account of the difference in recorded observations of men interested in the problem of gastrojejunal ulceration. Eggers raised the following question: "Are the proponents of conservative surgery less keen observers or are they dealing with a different kind of case?" He expressed the opinion that the discrepancy results largely from the type of patients selected for opera-

tion. He pointed out that the age, sex, and race of the patient, his environment, temperament and diet all have an impor-

tion can develop within a few days or may not develop for many years. Hunt has recently reported a case in which an ulcer



FIG. 1. Gastritis of the upper third of stomach, noted at necropsy approximately one year following extensive partial gastrectomy for gastrojejunal and recurring perforating duodenal ulcers.

tant bearing on the behavior of an ulcer and should guide the type of therapy to be carried out. He attributed most of the failures of gastroenterostomy to inadequate consideration of these factors and the performance of gastroenterostomy without proper indication. He deplored the sacrifice of half or more of the stomach in the treatment of an ulcer which is anatomically and physiologically separated from the stomach. He emphasized that failure to institute a medical regimen after gastroenterostomy is responsible for many recurrent ulcers.

At least a part of the discrepancy in reported figures can also be accounted for by the fact that it is impossible to set an arbitrary time limit for cure, as is done, for example, in carcinomatous lesions, where a five-year period without recurrence is accepted as a cure. Gastrojejunal ulceration

developed twenty-seven years after gastroenterostomy was performed. This factor makes it difficult for any investigator to determine accurately the ultimate success or failure of any operation for duodenal or gastric ulcer. At the same time operations that have relieved distress for many years cannot be regarded as complete failures. May not the recurring ulcer have developed after some unknown factor has lowered tissue resistance to gastric secretion and is it not possible that this factor has been in abeyance for the many years during which the patient has been symptom-free?

In our experience, gastrojejunal ulceration is an infrequent complication of the surgical treatment of duodenal ulcer and rarely develops subsequent to the surgical treatment of gastric ulcer. As regards the frequency of this complication, we feel that

the true incidence is probably much nearer to the low estimates mentioned previously than it is to the higher ones. When gastrojejunul ulceration occurs, it is a distressing complication and yet when surgical treatment is instituted early, disconnection of the gastroenteric anastomosis and removal of the gastrojejunul ulcer with a partial gastrectomy practically always prevent further ulceration in the jejunum and the risk of the operation is not great in the hands of the experienced gastric surgeon.

Our present viewpoint is that partial gastrectomy offers the greatest possible protection against recurrent ulceration. The difficulty lies in differentiating those cases of duodenal ulcer in which the added risk of this more radical procedure is justified from those in which gastroenterostomy will give satisfactory results with less risk. As long as we lack means of measuring the genetic factors of ulcer, tissue susceptibility to ulceration and predisposition to ulcer formation we must depend on a careful clinical study and analysis of each case, considering especially the age, sex, race, occupation and type of individual, the values for the acidity of the gastric contents and the results of roentgenologic and gastroscopic examination. Until the cause is discovered and more effective methods of control than we have at present are found, the incidence of gastrojejunul ulceration can probably best be controlled by emphasizing the necessity of drawing surgical indications more sharply and by selecting for each individual that type of surgical procedure which experience has shown will promise the best end results in each particular case. In other words, one should fit the operation to the patient and the lesion rather than use routinely the same type of operation in every case, regardless of the characteristics. It has been our experience that in cases in which active middle-aged men have a high gastric acidity and perforating or bleeding type of lesions, the operation of choice is usually primary extensive partial gastrectomy, provided it can be done safely. Yet, in

many such cases in which the extent of the duodenal ulceration or the condition of the patient has not seemed to warrant the increased risk of partial gastrectomy, a gastroenterostomy has been followed by excellent results and the ulcer has not recurred. In the case of older individuals, women, and patients who have a low gastric acidity or large perforating or obstructing lesions, the results of gastroenterostomy are so satisfactory and the incidence of gastrojejunul ulceration so small that we see no reason for assuming the greater risk of more radical procedures. If gastrojejunul ulceration does take place and the patient is reoperated upon early, the risk of the operation will frequently be less than it would be if a primary partial gastrectomy and duodenectomy with removal of the duodenal ulcer had been performed for the original duodenal ulcer. The duodenal ulcer will be found to have healed and its removal and the accurate closure of the duodenum will not be such a great problem and the risk will not be as great as when the duodenal ulcer was large and active and its removal would have left little duodenum to suture.

It has been our experience that gastroduodenal ulcerative disease occurs about four times as commonly among men as it does among women. Gastrojejunul ulceration is even more predominantly a disease of the male sex. In some large series of cases, the condition has occurred about seven to ten times as frequently among men as it has among women and in our series of 155 consecutive cases in which operation was performed for gastrojejunul ulcer at the clinic there were only three women; the ratio of men to women, therefore, was about 50:1.

Gastrojejunul ulceration may develop while the patient is still in the hospital recovering from the gastroenterostomy, although this is a rare occurrence; on the other hand, it may not develop for many years. The extremes of development in our series were twelve days and eighteen years. Other surgeons have had a similar experi-

ence. In our series of cases in which gastrojejunol ulceration developed, the average duration of good health and freedom from

occurred, extension of the pain to the left groin suggests a lesion of the left kidney or ureter. The periodicity of distress, which

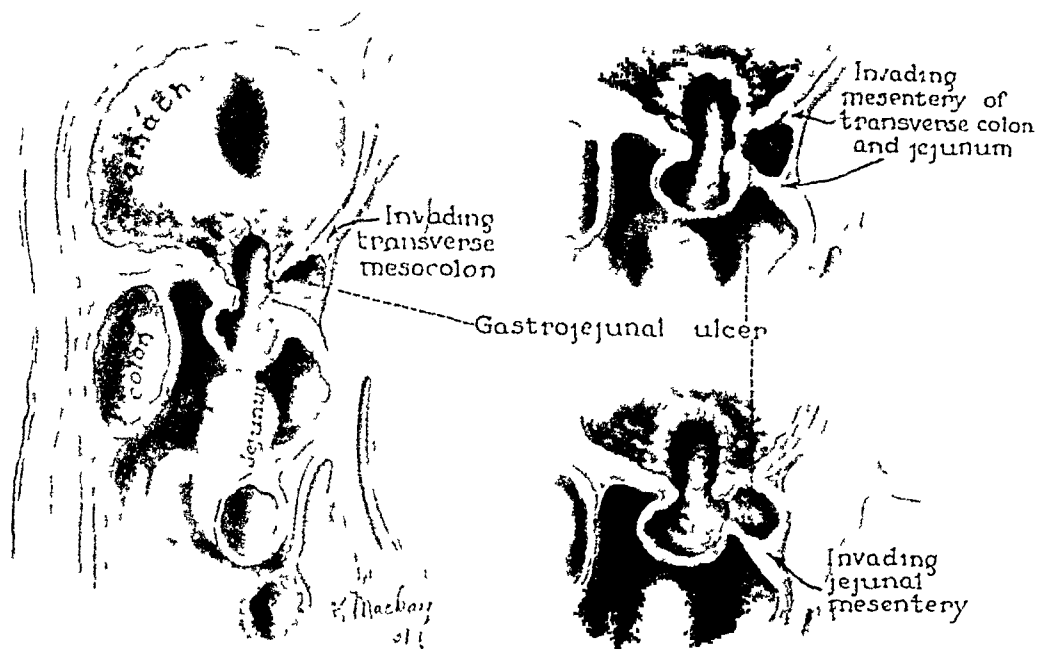


FIG. 2. Sites of perforation of gastrojejunal ulcer difficult to visualize roentgenographically.

ulcer symptoms following gastroenterostomy was 2.98 years. In the majority of cases the patients were between 30 and 50 years of age.

#### DIAGNOSIS

The diagnosis of gastrojejunol ulceration is not difficult as a rule. The symptoms are, in many respects, similar to those of duodenal or gastric ulceration. There is a gnawing, hunger pain which comes on between meals and occasionally awakens the patient at night. The pain may be relieved by food or alkalis, but it may not be as amenable to control as was the distress of the original lesion. The pain may be epigastric, but frequently has shifted below and to the left of the site of the original distress. Extension of the pain posteriorly is common and may be very severe, especially if the ulcer has perforated against the mesocolon or to the mesentery of the jejunum. (Fig. 2.) Sometimes, when subacute perforation of the ulcer has

was characteristic of the original ulcer, may not be as definite in case of secondary ulcer and the periods of relief are often incomplete. On the other hand, gastrojejunol ulceration may be symptomatically silent until a sudden hemorrhage calls attention to the presence of ulceration. Hemorrhage is a very frequent complication of gastrojejunol ulceration. Gross hemorrhage occurred in 52.9 per cent of our series of cases. Vomiting is also common; in 49.7 per cent of our cases there was a history of this symptom. Perforation of the gastrojejunol ulcer into the transverse colon with development of a gastrojejuno-colic fistula has been estimated to occur in from 9 to 19 per cent of cases of gastrojejunol ulcer. In the period in which the 155 consecutive cases of gastrojejunol ulcer were observed at the clinic twenty-three cases of gastrojejuno-colic fistula were observed.

Although roentgenologic studies are of considerable value and should be carried out routinely in cases of suspected gastro-

jejunal ulceration, it should be pointed out that they cannot be expected to demonstrate ulceration in every case in which ulceration is found on surgical exploration. In competent hands, however, roentgenologic accuracy is very satisfactory. Dr. B. R. Kirklin reported that the roentgenographic findings were positive in fifty-three, or 91.4 per cent, of fifty-eight cases of gastrojejunal ulcer in which operation was performed at the clinic during 1938. In seventeen, or 29.3 per cent, of these cases the roentgenographic report was jejunitis or a poorly functioning gastroenteric stoma and in thirty-six, or 62 per cent, it was gastrojejunal ulcer. Gastrojejunal ulcer was reported in thirty-seven cases on roentgenographic examination and at operation gastrojejunal ulcer was found in thirty-six of these cases. In the other case the surgical diagnosis was obstruction of the gastroenteric stoma. In only five, or 8.6 per cent, of fifty-eight cases, was the roentgenographic report negative. In other words, although roentgenoscopy failed to demonstrate a definite ulcer crater in 38 per cent of cases (Fig. 2) in which gastrojejunal ulceration was found at operation it disclosed definite abnormality of the appearance and function of the gastroenteric stoma in 91.4 per cent. A roentgenologic diagnosis of gastrojejunal ulceration was extremely reliable, as an ulcer was found at operation in 97.3 per cent of the cases. Kelly has found in his experience that roentgenography is not always a dependable diagnostic procedure in gastrojejunal ulcer as the irregularities caused by the gastrojejunal anastomosis make visualization of the involved region difficult, especially if the ulcer crater is small.

Gastrosopy is becoming an increasingly valuable addition to our diagnostic armamentarium. It is not indicated as a routine procedure and in no way infringes upon the place of roentgenologic examination in the diagnosis of gastrojejunal ulcerations, but as an adjunct to other methods of diagnosis it is extremely valuable. It is especially indicated and of value in cases in which the

roentgenologic findings are indefinite or negative, but in which the clinical findings suggest the presence of gastrojejunal ulceration. Moersch said that it is frequently possible to look directly into the gastroenteric stoma with the gastroscope and even in cases in which this is impossible there may be other direct visual evidence of ulceration, inflammation or malfunction of the anastomosis.

In the absence of any reliable diagnostic or laboratory procedure, the diagnosis of gastrojejunal ulceration must and should depend on a careful analysis and evaluation of all the information that can be gained from the history and physical findings and from the laboratory, roentgenologic and gastroscopic investigations. Surgical treatment should be advised when the diagnosis is made. Gastrojejunal ulcer is rarely healed under a medical regimen.

#### SURGICAL TREATMENT OF GASTROJEJUNAL ULCERATION

The development of gastrojejunal ulceration according to our present conception of the disease indicates two things: first, that the patient has a definite predisposition to the development of ulceration or a tissue susceptibility to ulceration, and, second, that the ulcer-forming tendencies of that individual have not been adequately controlled by the procedure that has been performed whether it has been gastroenterostomy or gastric resection. An individual who has a gastrojejunal ulcer is an "ulcer former," and in most instances a surgical procedure which will permanently alter the gastric physiology and permanently control the gastric acids is imperative if recurrent ulceration is to be prevented. The procedure which will most satisfactorily meet these requirements has in our experience been partial gastrectomy of the posterior Polya type, if gastrojejunal ulceration occurs after gastroenterostomy, and more extensive gastric resection if a partial gastrectomy has been performed previously.

*Disconnection of Gastroenteric Anastomosis Followed by Gastroduodenostomy or Pyloroplasty.* A disconnection of the gastroenteric anastomosis, excision of the ulcer, closure of the openings in the stomach and jejunum, and either a pyloroplasty or a gastroduodenostomy have been procedures frequently used in the surgical treatment of gastrojejunal ulceration, based on the premise that they are less radical procedures than partial gastrectomy and yet offer a considerable measure of protection against recurrence of ulceration by reason of the regurgitation of duodenal contents through the stoma into the stomach, by relief of pylorospasm and by increasing the emptying time of the stomach. Time has shown the relative inefficiency of this procedure. In our series of 155 consecutive cases in which operation was performed for gastrojejunal ulcer this procedure was carried out in sixty-eight cases. Seven patients died postoperatively, a mortality of approximately 10 per cent. We were unable to get information concerning twelve patients in this group. There was definite recurrence of duodenal ulceration in twenty, or in 40.8 per cent, of the cases in which we were able to obtain follow-up data. Recurrence was found by reexamination at the clinic or by operation in these twenty cases. In nine of these twenty cases partial gastrectomy has been performed at the clinic or elsewhere. One patient now has roentgenologic and clinical evidence of jejunal ulceration after partial gastrectomy. Five additional patients have had recurrent symptoms of gastrojejunal ulceration and gross hemorrhage subsequent to disconnection of the gastroenteric stoma and performance of gastroduodenostomy, and may be presumed to have recurrent duodenal ulceration. Seven patients have had definite recurring symptoms but no bleeding. Nine patients have a moderate amount of distress, but have gotten along rather well with medical management. Only eight patients have obtained entirely satisfactory results.

*Removal of Gastroenteric Anastomosis.* Disconnection of the gastrojejunal anastomosis and restoration of normal gastrointestinal continuity without a plastic procedure on the outlet of the stomach were carried out in twenty-five cases with a mortality of 8 per cent. We were unable to trace two patients. Seven, or 33.3 per cent, of the twenty-one patients who could be traced have had recurrence of duodenal ulceration. Three of these seven patients had undergone a partial gastrectomy. Four patients have had symptoms that suggest recurrence, but ulceration has not been proved. Ten patients have gotten along very satisfactorily without any distress of consequence.

*Plastic Procedures on the Gastroenteric Stoma.* A plastic procedure on the gastrojejunal stoma without disconnection of the anastomosis was performed in four cases. One patient died, one obtained a satisfactory result and the other two had a definite recurrence of gastrojejunal ulceration.

*Disconnection of Posterior Gastroenteric Anastomosis and Establishment of an Anterior Gastroenteric Anastomosis and Enteroanastomosis.* This procedure was carried out in four cases. One patient died, and there was definite recurrence of gastrojejunal ulceration in the remaining three cases.

*Disconnection of Gastroenteric Anastomosis and Performance of Billroth I Resection.* A disconnection of the gastroenteric anastomosis followed by excision of the ulcer, closure of the opening in the jejunum and a Billroth I type of resection was performed in six cases. Three patients obtained very satisfactory results. There has been definite recurrence of duodenal ulceration in two cases and the symptoms suggest recurrence in the third case.

*Disconnection of Gastroenteric Anastomosis and Performance of Anterior Polya-Balfour Resection.* A disconnection of the gastroenteric anastomosis followed by an anterior Polya-Balfour type of resection with enteroanastomosis was performed in seven cases. Two patients died postopera-

tively. There has been definite evidence of recurrent gastrojejunal ulceration on examination at the clinic in two cases, one patient has symptoms suggesting recurrence and two patients are in excellent health.

*Disconnection of Gastroenteric Anastomosis and Performance of Posterior Polya Resection.* This procedure was carried out in thirty-nine cases. Two patients died; therefore, the surgical mortality was 5.1 per cent. Three could not be traced. There has been definite recurrence in four, or 11.7 per cent of the cases in which the patients could be traced. Three of these four patients have since had second resections of the stomach performed. Three patients have had considerable distress suggesting recurrent ulceration but no bleeding and no definite evidence of ulceration. Twenty-seven, or 79.4 per cent, of the patients who survived the operation have obtained satisfactory results.

*Miscellaneous Procedures.* In one case the gastrojejunal ulcer was so large and the condition of the patient so poor that a jejunostomy was done for feeding, in the hope that placing the gastrojejunal anastomosis at rest would decrease the size of the ulcer. In spite of this the patient died.

In another case there was a very large gastrojejunal ulcer with impending perforation to the colon. The mass was so large that it seemed advisable to resect the portion of the jejunum and colon containing the ulcer, restore the continuity and close the opening in the stomach. This patient we have been unable to trace.

#### COMMENT

The various surgical procedures, such as disconnection of the gastroenteric anastomosis alone or combined with a plastic procedure on the outlet of the stomach, various plastic procedures on the gastrojejunal stoma, disconnection of the posterior gastroenteric anastomosis and establishment of an anterior gastroenteric anastomosis, have given unsatisfactory results

in a majority of cases of gastrojejunal ulcer. Yet in a definite percentage of cases in each group good results were obtained. Patients who have gastrojejunal ulcer are "ulcer formers" and as such require a surgical procedure that will control their ulcer-forming tendencies. In many cases, however, it must be pointed out that the patients were in rather poor condition and the conservative procedures carried out were often those of necessity rather than those of choice, the patient's condition seeming to prohibit partial gastrectomy which might, to a great extent, have prevented recurrent ulceration. In such cases we now believe that the operation should be divided into two stages; the first stage should include the treatment of the gastrojejunal ulcer and the second stage, which should be performed when the patient is in good condition, should attempt to control the patient's ulcer-forming tendencies by means of partial gastrectomy. The only objection to this is that if recurrence of the duodenal ulcer takes place after disconnection of the gastroenteric anastomosis it usually shortens the duodenum and makes removal of the ulcer and closure of the short stump of duodenum hazardous.

It is readily apparent that extensive partial gastrectomy of the posterior Polya type has given the best results in selected cases, and, interestingly enough, with the lowest risk in the treatment of gastrojejunal ulcers. It is the only procedure which can be depended upon to decrease adequately the concentration of hydrochloric acid in gastric secretion and hence remove the exciting factor whose effect upon the sensitive jejunum is less likely to produce recurring ulceration than if reduction and dilution of gastric acidity had not been obtained. The operation may be difficult. It is best and most safely performed by those accustomed to performing difficult gastric operations. The resection should include the pylorus and two-thirds or three-fifths of the stomach if gastric acidity is to be adequately reduced.



The importance of including the pylorus in resections of the stomach for duodenal ulcer is not generally appreciated. However, there is extensive experimental and clinical evidence which shows conclusively that this is an essential part of the operation. Edkins was probably the first to point out that the pylorus in some way controlled the acid secretion of the stomach. He found that peptones and other meat extracts acted on the mucous membrane of the pylorus to produce a hormone which led to an increased flow of acid gastric juice. Wilhelmj and his associates have confirmed this observation and have concluded from their studies that after removal of the pylorus, owing to removal of its specific stimulating influence, the quantity of acids in the gastric contents was definitely reduced. Lorenz and Schur have also shown that removal of the pylorus decreases the production of hydrochloric acid and lessens the probability of recurrent ulceration. Ogilvie<sup>24</sup> noted that in cases in which he did not resect the pylorus the curve representing the gastric acidity was high postoperatively as compared to those cases in which he included the pylorus in the partial gastric resection. In six of twenty-two cases in which the pylorus was not resected he reported that further operation was required for jejunal ulcer while in 100 cases in which partial resection, including the pylorus, was performed there was no recurrent ulceration. Friedemann, in a review of a series of 2,250 cases in which partial gastric resection was performed, noted a recurrence of ulcer in 4 per cent of his early cases and in only 0.5 per cent of his later cases in which he did a more radical operation, including resection of the pylorus in every case. Spath and Friedemann have both reported recurrence after partial gastric resection, but subsequent removal of the pylorus lowered the gastric acidity and healed the ulcer.

Removal of the pylorus adds somewhat to the difficulty of the operation since it requires freeing of the duodenum. In some cases of perforating duodenal ulcer this is

quite difficult but we feel that it should be a part of every partial gastric resection for duodenal ulcer or recurring ulceration. Some of the difficulties of closure of the duodenum can be obviated by removing the mucosa of the pylorus without the muscle, as suggested by Engel.

#### SUMMARY

Gastrojejunal ulceration is an uncommon complication of the surgical treatment of gastroduodenal ulcerative disease. It is essentially a complication of the surgical treatment of duodenal ulcer. It rarely develops subsequent to surgical procedures for gastric ulcer and seldom occurs among women. It can best be prevented by drawing surgical indications more sharply by performing primary partial gastrectomy in those cases of duodenal ulcer in which experience has shown that gastrojejunal ulcer is likely to develop and by emphasizing the necessity of maintaining a reasonable medical management following the operation of gastroenterostomy.

The diagnosis is usually not difficult, but should depend upon clinical evaluation of the patient's history, roentgenologic examination of the stomach, duodenum, gastroenteric stoma and the jejunum. Such roentgenologic studies may fail to reveal the presence of a gastrojejunal ulcer in 38 per cent of the cases, even when craters are present, although deformity of the gastroenteric stoma can be demonstrated in about 91 per cent of such cases.

Extensive partial gastrectomy of the posterior Polya type has given the best results with the lowest operative mortality when the condition of the patient permits the use of the procedure. If it does not, partial gastrectomy can be done as a secondary procedure, after the patient recovers from the disconnection of the gastroenteric anastomosis and excision of the gastrojejunal ulcer. Although the results of other less radical surgical procedures may be satisfactory in about half of the cases, in the other half, recurrence of the duodenal ulcer will take place, necessitating partial

gastrectomy. This will be more difficult and will be associated with an increased risk owing to the shortening of the duodenum as the result of the recurring duodenal ulcer.

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# GASTROJEJUNOCOLIC ULCER AND FISTULA .

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**G**ASTROJEJUNOCOLIC fistulas present a formidable surgical problem.

The corrective operative procedures combine the hazards of a gastric operation with the risks of operation on the colon in a case in which the patient usually is debilitated, emaciated, and anemic as a result of the nutritional disturbances resulting from the fistula. Although gastrojejunocolic fistulas occur in association with malignant lesions, they are almost always secondary to gastrojejunal ulceration and secondary to a posterior gastrojejunal anastomosis, with or without gastric resection. Surgical treatment should include not only removal of the gastroenteric stoma, closure of the colonic fistula and reestablishment of gastrointestinal continuity, but also should control the ulcer-forming diathesis of the patient, at the same time if the condition of the patient permits, or later if it does not. Frequently, it is wisest and safest to perform the operative procedures in more than one stage. The necessity of surgical treatment lies in the inability to control the nutritional disturbances by any measures which do not allow an adequate diet to be assimilated from the small intestines.

## ETIOLOGY

Prior to the development of posterior gastroenterostomy in the treatment of benign ulcers of the stomach and duodenum, fistulas between the stomach and colon very rarely were produced by malignant lesions of the stomach ulcerating into the colon or vice versa. Gastrocolic fistula secondary to a malignant lesion was first reported by Haller, in 1755. In 1900, Zweig was able to collect seventy cases from the literature and, in 1925, Verbrugge reported 121 cases in which gastrocolic fistula

occurred secondary to carcinoma of the colon and stomach. Brinton, in a study of 505 cases of carcinoma of the stomach, found eleven instances of gastrocolic fistula, an incidence of 2.1 per cent. As mentioned previously, this complication is now rarely seen, owing to earlier diagnosis and treatment. As recently as 1936, however, Louria and Rothstein reported a case in which gastrocolic fistula was secondary to carcinoma of the stomach. Malignant lesions of the stomach or colon may be strongly suspected in cases of gastrocolic fistula if there is no history that gastroenterostomy has been performed.

According to Glickman, abscess in the peritoneal cavity, tuberculosis and congenital anomalies may rarely result in a gastrocolic fistula. Bargen and his associates have reported one case in which gastrocolic fistula was secondary to chronic ulcerative colitis.

At present, most gastrocolic ulcers and fistulas are secondary to gastrojejunal ulcers which occur after gastroenterostomy has been performed for benign ulcers of the duodenum. The infrequent development of these complications following the establishment of a properly functioning gastroenteric anastomosis should be emphasized, however, as gastroenterostomy in properly selected cases is an operation of great value and is associated with a low operative risk. It has been the past experience at The Mayo Clinic that gastrojejunal ulceration occurs in only about 3 to 4 per cent of cases in which the operation is performed.<sup>2</sup> It rarely occurs when it is a part of an operative procedure for gastric ulcer and seldom occurs among women. Walton reported only one instance of gastrojejunal ulcer in 683 cases in which gastroenterostomy was performed for gas-

tric ulcer, as compared with twenty-nine instances in 893 cases in which the operation was performed for duodenal ulcer. In thirteen of Rife's series of fourteen cases of gastrojejunal fistula the original lesion was a duodenal ulcer. Rife reported one case in which gastrojejunal fistula followed palliative gastroenterostomy for carcinoma of the stomach. In ten of seventy-six cases of gastrojejunal ulcer reported by Loewy, gastroenterostomy had been performed for gastric ulcer. As a rule, however, gastrojejunal ulceration is a result of failure of the gastroenteric anastomosis to control the gastric hyperacidity adequately, a continued lower tissue resistance to gastric secretion and an ulcer-forming tendency on the part of patients who have a duodenal ulcer. Failure to follow a reasonable medical regimen postoperatively may be an important factor in the development of this complication.

#### INCIDENCE

Although gastroenterostomy was first performed in 1881 and gastrojejunal ulcer was reported by Braun in 1899 and by Quénu in 1902, it was not until 1903 that the first instance of gastrojejunal fistula was reported by Czerny. In this case the lesion was removed by a block resection of the stomach, jejunum and colon, and a new gastroenteric anastomosis was established. In 1925, Verbrugge reviewed the literature and found reports of ninety-five cases in which gastrojejunal fistula occurred after gastroenterostomy had been performed for peptic ulcer. Verbrugge reported that a jejunal or gastrojejunal ulcer developed in eighty-eight, or 1.41 per cent, of 6,214 cases in which gastroenterostomy was performed for both gastric and duodenal ulcers at The Mayo Clinic prior to January, 1924. A gastrojejunal fistula developed in ten, or 11.36 per cent, of the eighty-eight cases. In other words, a gastrojejunal fistula developed in only ten, or 0.16 per cent, of the 6,214 cases in which gastroenterostomy was performed. Allen reported that the incidence of gastro-

jejunal fistula was 14 per cent in thirty-six cases of gastrojejunal ulcer. A gastrojejunal fistula was present in twenty-three, or 13.6 per cent, of 169 cases of gastrojejunal ulcer in which operation was performed at the clinic in the years 1933 to 1936 inclusive. In the ten-year period, 1928 to 1937 inclusive, operation for gastrojejunal fistula was performed in fifty cases at the clinic. In the same period there were seventeen cases in which operation disclosed an impending fistula, that is, a gastrojejunal ulcer which would apparently have perforated the colon if operation had not been performed.

Gastrojejunal fistula is almost exclusively found among men. In one of the fourteen cases reported by Rife the patient was a woman. In the ninety-five cases reported by Verbrugge one of the patients was a female and in our series of fifty cases of gastrojejunal fistula and seventeen cases of impending fistula only one of the patients was a woman. This incidence is roughly in proportion to the ratio of incidence of gastrojejunal ulcer in the two sexes (we noted only three instances of gastrojejunal ulcer in women in a series of 155 cases) and supports our belief that gastroenterostomy is a safe and usually a satisfactory procedure for the treatment of duodenal ulcer in the female. The incidence of gastrocolic fistula secondary to malignant lesions of the stomach and colon in men and women is in almost direct proportion

TABLE I  
AGE OF PATIENTS IN FIFTY CASES OF GASTROJEJUNOCOLIC  
FISTULA AND IN SEVENTEEN CASES OF IMPENDING  
FISTULA

Age, Years	Gastrojejunal Fistula	Impending Gastrojejunal Fistula
20 to 30....	5	2
30 to 40....	5	4
40 to 50....	25	10
50 to 60....	13	
60 to 70....	2	1
	50	17

to the incidence of the original lesion in the two sexes. According to Lahey and Swinton, in most cases of gastrojejuno-colic fistula the patients are between 30 and 45 years of age. The average age of the patients in Rife's series of cases was 46 years. In most of the cases in our series the patients were between 40 and 60 years of age. (Table 1.)

#### PATHOLOGY

Gastrojejuno-colic fistula seldom occurs after an anterior gastroenterostomy has been performed. It is generally agreed that gastrojejunal fistula cannot occur unless a gastrojejunal ulcer has been present for some time. The fistulous tract is almost always between the jejunum and transverse colon in cases of peptic ulcer. Direct fistulas between the stomach and colon are rare in cases of peptic ulcer. The fistulous tract usually is close to but below the site of the gastroenteric anastomosis and is smooth and clean. There is rarely ulceration of the tract itself. Occasionally, the original gastrojejunal ulcer will be found to be healed. The diameter of the fistulous tract may vary from a few millimeters to 2 cm. or more. There is usually only one fistula. Regurgitation usually occurs from the colon into the jejunum and into the stomach owing to a valve-like action at the site of communication. For this reason, a fistula may not be apparent when the upper part of the gastrointestinal tract is studied roentgenoscopically with a barium meal, but will quickly become evident after administration of a barium enema. The efferent loop of jejunum is usually dilated and hypertrophied. The colon is often constricted at the site of the fistula and dilated proximally. The distal portion of the colon is usually congested, inflamed and even ulcerated by the acid gastric secretions.

#### SYMPTOMS AND DIAGNOSIS

The diagnosis of gastrojejuno-colic fistula is usually not difficult. As mentioned pre-

viously, the condition usually affects men who are between 40 and 50 years of age. It usually occurs in cases in which a posterior type of gastrojejunal anastomosis with or without resection has been performed in cases of duodenal ulcer. There is usually a rather long history of recurring symptoms of ulcer. In our series of cases the average duration of ulcer symptoms before gastroenterostomy was nine years. As mentioned previously, a fistula does not occur unless gastrojejunal ulceration has been present for some time. In our series of cases the average length of time that elapsed between the gastroenterostomy and the development of a fistula was forty-five months. In Rife's series of fourteen cases it was four and a half years.

The symptoms are those of recurrence of ulcer distress after gastroenterostomy. There often may be severe pain which is followed after some months by the development of a persistent diarrhea. Usually, the pain ceases with establishment of the fistula. The stools are watery, acholic, and often contain large quantities of undigested food. There is frequently a very bad taste in the mouth; the patient belches foul gas and sometimes vomits material which is definitely fecal. There is often marked loss of appetite but occasionally the patient has a voracious appetite. Marked loss of weight owing to the short circuiting of food from the upper part of the intestinal tract is almost invariable. Dehydration and emaciation, often to an extreme degree, are common. Nutritional and vitamin deficiency states are frequently encountered and in cases in which the condition is advanced there may be a serious degree of anemia.

Physical examination usually reveals evidences of severe nutritional disturbances and occasionally an inflammatory mass can be palpated in the epigastrium. Positive roentgenologic evidence is not necessary for a diagnosis of gastrojejuno-colic fistula. Balfour and Eusterman reported the results of roentgenologic examination in twenty cases in which the diagnosis of

gastrojejunocolic fistula was verified at operation. The roentgenologic findings were positive in eleven cases, doubtful in one case and negative in eight cases. During roentgenoscopic examination the fistula can usually be visualized more satisfactorily following the administration of a barium enema than it can following the administration of a barium meal.

#### TREATMENT

In a discussion of the treatment of gastrojejunocolic fistula, the first consideration should concern the method of preventing this complication. Since nearly all gastrojejunocolic fistulas follow posterior gastroenterostomy which usually is performed for duodenal ulcer, it is apparent that the same factors that contributed to the original lesion also contribute to the development of the gastrojejunal ulcer and the subsequent colonic fistula, and that the gastroenterostomy has failed to control the ulcer-forming factors adequately. The failure of posterior gastroenterostomy to control the ulcer-forming factors in an occasional case should not, however, result in a widespread condemnation of posterior gastroenterostomy in the surgical treatment of duodenal ulcer. This procedure has given satisfactory results in more than 90 per cent of cases for a great many years and is still a safe and valuable method of treatment in properly selected cases.

The occasional failure of gastroenterostomy and the possibility of development of disturbances of motility at the site of the anastomosis may be due to an improper selection of cases in which the procedure is used. In our experience posterior gastroenterostomy is applicable and the treatment of choice in the following cases: (1) cases of large obstructing duodenal ulcer in which the patients are elderly individuals; (2) most cases of obstructing duodenal ulcer in which the patients are women; (3) cases in which there is a low concentration of hydrochloric acid in the gastric contents; (4) some cases of subacute and acute

perforating duodenal ulcer; and (5) cases of duodenal ulcer in which the patients are in poor physical condition. On the other hand, primary partial gastric resection seems to be the procedure of choice in cases of duodenal ulcer in which the patients are middle-aged men and the concentration of hydrochloric acid in the gastric contents is high, and in cases in which the lesion is of the hemorrhagic type. Primary partial gastric resection is also often indicated if the patient's occupation or his temperament is such that a regulated dietary regimen and elimination of acid stimulating factors, principally nicotine and alcohol, will not be followed.

In other words, we feel that gastrojejunocolic ulcer and fistula can best be prevented, not by discarding posterior gastroenterostomy, but by limiting its use to the type of case in which experience has shown it can be depended upon to give good results and by using primary partial gastric resection in those cases in which a gastrojejunal ulcer is liable to develop. We feel sure that gastrojejunocolic ulcer and fistula will become less of a problem in the future as the indications for gastroenterostomy and gastric resection are better understood and appreciated. Gastrojejunal ulcer will also become less frequent as patients with duodenal ulcer are brought to realize the necessity of continuing a reasonable medical regimen postoperatively. In those cases in which gastrojejunal ulcer unfortunately develops, colonic ulcer and fistula can best be prevented by earlier diagnosis of the ulcer and prompt surgical treatment. In our series of cases an average interval of four and a half years had elapsed between the performance of gastroenterostomy and development of fistula. This fact emphasizes the necessity of a postoperative follow-up in all cases in which operation is performed for a gastric or duodenal ulcer, in order that a recurrent ulcer can be recognized in its incipiency and treated before serious complications develop.

In cases of duodenal ulcer, gastrojejunocolic fistula may also be prevented by an

anastomosis of the jejunum to the stomach anterior to the colon rather than posterior, as the anterior procedure prevents the gastrojejunal anastomosis from coming into contact with the colon and thus prevents a gastrojejunal ulcer from extending into the colon. Furthermore, if secondary operative procedures for recurring ulceration should become necessary they are usually easier and safer to perform if an anterior anastomosis has been made, because the gastroenteric stoma is more readily exposed and mobilized. However, it has been our experience that stasis occurs in the proximal loop and necessitates an enteroanastomosis because of the longer loop of jejunum necessary in the performance of an anastomosis anterior to the colon. Such an enteroanastomosis decreases the amount of alkaline intestinal secretion that enters the stomach and hence the reduction in the acidity of the gastric contents is not comparable to that which occurs when an enteroanastomosis is not made. This may be a deciding factor in the development of a gastrojejunal ulcer in a case in which the tissue of the jejunum lacks resistance to the acid gastric secretion. The importance of tissue resistance is evidenced by the fact that clinical experience has shown that anterior anastomosis with enteroanastomosis produces very good results in many cases.

The surgical management of a fully developed gastrojejunocolic fistula is hazardous and difficult owing to the poor condition of most of the patients and to the previous surgical procedures. However, surgical intervention offers the only hope. Operation should be attempted as soon as the physical condition of the patient will warrant such a procedure.

Several days of preoperative hospitalization are usually necessary. During this time the dehydration and anemia can be treated by intravenous administration of fluids and by transfusion. The stomach and bowel should be cleansed as thoroughly as possible by gastric lavage and by enemas. During this

time a highly nutritious diet should be used and vitamin preparations should be administered.

The operative procedure to be carried out in an individual case can only be determined after examination of the lesion and an estimation of its extent. All procedures must be performed with a most meticulous technique to prevent contamination from the colon.

The various types of operative procedures performed at the clinic in our series of cases of gastrojejunocolic fistula and impending fistula are shown in Table II.

TABLE II  
OPERATIVE PROCEDURES EMPLOYED IN FIFTY CASES OF  
GASTROJEJUNOCOLIC FISTULA

Operative Procedure	Cases
Disconnection of gastroenteric anastomosis; closure of the openings in the stomach, jejunum and colon.....	18
Disconnection of gastroenteric anastomosis; closure of the openings in the stomach, jejunum and colon; gastric resection.....	9
Disconnection of gastroenteric anastomosis; closure of the openings in the stomach, jejunum and colon; pyloroplasty.....	14
Disconnection of gastroenteric anastomosis; closure of the colic fistula at the site of the gastroenteric anastomosis.....	2
Disconnection of posterior gastroenteric anastomosis; anterior gastroenterostomy and enteroanastomosis.....	3
Other procedures.....	4
Total.....	50

It is apparent that no one procedure is applicable to every case of gastrojejunocolic fistula and that the surgeon must have a wide variety of procedures at his command in order to be able to contend adequately with all the problems encountered. It is well known that in cases of gastrojejunal ulcer and gastrojejunocolic fistula there is a weakened tissue resistance to peptic ulceration; in other words, there is an ulcer-forming diathesis. Experience has shown that prevention of recurrent ulceration in such cases requires radical measures and that extensive partial gastrectomy is the procedure which most adequately controls the ulcer-forming tendencies. It becomes apparent, therefore, that the surgical treatment of gastro-

jejunocolic fistula usually must include extensive partial gastrectomy. Since it is frequently not advisable to perform such an extensive operation on an emaciated, debilitated patient because of the poor operative risk, the operation often should be divided into two stages. The first stage includes restoration of the gastrointestinal continuity in order to permit adequate nutrition, and the second stage, which should be performed after the patient has regained his strength, should attempt to control the ulcer-forming tendencies permanently.

A simple removal of the posterior gastroenteric anastomosis with closure of openings in the stomach, jejunum, and colon is probably the safest procedure that can be carried out in cases of gastrojejunocolic fistula. This procedure is applicable if the pylorus and duodenum are patent, if the fistula is small, and if there is not too much inflammatory reaction about the fistula. It may be necessary to add a pyloroplasty to this procedure in order to relieve duodenal obstruction caused by contraction of the original duodenal ulcer. Great care must be taken with all steps of the procedure. All adhesions should be divided and structures freely mobilized before attempting to disconnect the gastroenteric anastomosis. Contamination from the colonic fistula must be prevented by careful packing off the contents of the rest of the abdominal cavity and by careful surgical technique. Closure of the fistula should be the first consideration as soon as the colon is freed from the jejunum and stomach. The opening in the colon is closed with catgut sutures and the site of the fistula is inverted with interrupted silk sutures. The silk sutures should be placed in healthy tissue away from the infected, inflamed tissue surrounding the fistula. A pad of omentum which has been tacked over the site of the fistula will help prevent any leakage. Openings in the stomach and jejunum are then closed by using three rows of sutures; the two outer rows consist of interrupted silk sutures. The opening in

the mesocolon is closed with interrupted catgut sutures. The operative field is then carefully irrigated with physiologic saline solution at body temperature. Reconstruction of the gastric outlet in order to eliminate duodenal obstruction can then be performed if necessary. It should be kept in mind, however, that this procedure may add to the difficulties of closure of the duodenum if partial gastric resection at a later date becomes necessary; therefore, the procedure should not be performed unless the pylorus or duodenum is badly constricted.

In cases of gastrojejunocolic fistula in which the fistula is large and there is considerable inflammatory reaction around the anastomosis, more extensive procedures, such as en bloc resection of the jejunum and colon or stomach, may be necessary. This is such a formidable and hazardous procedure that it should be attempted as a one-stage procedure only as a last resort. In the experience of one of us (Walters) this has never been necessary. Recently, Pfeiffer has noted improvement in the patient's condition and a decrease in the size of the fistula after performance of a colostomy proximal to the gastrojejunocolic fistula. Lahey and Swinton have suggested a two-stage procedure in such cases. The stomach is sectioned above the site of the gastroenteric anastomosis. The proximal end is anastomosed to the jejunum below the site of the gastroenteric anastomosis and the distal end of the stomach is closed. At a later date, after the patient has regained his strength, a resection of the distal portion of stomach and closure of the openings in the colon and jejunum is performed.

Occasionally, disconnection of the gastroenteric anastomosis with closure of the openings in the stomach and jejunum and exteriorization of the portion of the transverse colon in which the fistula is situated is a safer procedure, especially if the fistula is large or if there is stenosis of the colon at the site of the fistula which may cause obstruction. This procedure results in a



double barrel type of colostomy which can be closed at a later date.

In cases of gastrojejunal fistula Scrimger has devised a technique in which he performs a gastric resection and leaves a cuff of stomach around the anastomotic ulcer. The gastric mucosa is dissected from the flaps which are sutured firmly together. The proximal end of the stomach is anastomosed to the jejunum distal to the fistula, as in any Polya type of resection. He made no attempt to deal with the fistula between the jejunum and colon as he believed that it would almost invariably close after diversion of the gastric contents. Estes, in 1932, described a procedure which was very similar to that suggested by Scrimger.

Allen has suggested en masse resection of the colon, jejunum and stomach by using the Kerr aseptic technique of anastomosis for restoration of gastrointestinal continuity. This method largely prevents contamination of the abdominal cavity, but frequently it may be technically very difficult, especially in cases in which there is a short jejunal loop proximal to the gastroenteric anastomosis.

Kelly preferred to operate on gastrojejunal fistulas in one stage. He advised taking down the gastroenteric anastomosis, closing the fistula or even resecting a portion of the colon, closing the jejunum and then completing the operation with an extensive partial gastric resection of the Polya type. He has carried out this procedure eight times with two deaths.

Finsterer preferred to carry out the operative procedures in one stage but said that a two-stage procedure is advisable if a simple closure of the colonic fistula is impossible. He reported thirteen cases with five deaths.

It is our opinion that although a one-stage extensive partial gastric resection of the stomach is greatly to be desired, it should not be carried out with excessive risk to the patient's life. In most of these cases the first consideration should be concerned with the restoration of a gastro-

intestinal continuity which will allow a return to normal nutrition and good general health. Control of the ulcer-forming tendencies should be a secondary consideration. We believe that in most cases the surgical treatment of gastrojejunal fistula can be carried out as a two-stage procedure with considerably less risk than as a one-stage procedure. However, the patient must be impressed with the fact that the second stage of the operation, which includes gastric resection, is an integral part of the treatment and that it should be carried out as soon as his condition will permit. The resection should be carried out before recurrent duodenal ulcer has had an opportunity to develop, since an acute duodenal ulcer would interfere materially with closure of the duodenal stump. The patient must also follow a rigid medical management during the interval.

The danger of any surgical procedure in cases of gastrojejunal fistula is extremely high owing to the patient's poor condition and the extensive procedures necessary. Allen reported a mortality of 25 per cent in eight cases; Lahey and Swinton, an immediate mortality of 63 per cent in eight cases; Rife, a mortality of 20 per cent in fourteen cases, and Wilkie, a mortality of 40 per cent in his series of cases. There was a mortality of 32 per cent in the fifty cases in which operation was performed at the clinic in the years 1928 to 1937 inclusive.

#### GASTROJEJUNAL ULCER WITH IMPENDING GASTROJEJUNOCOLIC FISTULA

Table III indicates the operative procedures carried out in seventeen cases of impending gastrojejunal fistula seen at the clinic in the years 1928 to 1937 inclusive. In these cases a gastrojejunal ulcer had penetrated so deeply into the walls of the colon that perforation would have been inevitable if operation had not been performed. These cases are included because they present a strong argument for early surgical treatment of gastro-

jejunal ulcer. When operation can be performed before a gastrojejunal fistula has developed, the surgical risk is much less than it would be if operation were delayed until a fistula had developed. It is thus possible to perform partial gastric resection in a greater number of cases.

TABLE III

OPERATIVE PROCEDURES EMPLOYED IN SEVENTEEN CASES OF IMPENDING GASTROJEJUNOCOLIC FISTULA

Operative Procedure	Cases
Disconnection of gastroenteric anastomosis and resection of the stomach	11
Disconnection of gastroenteric anastomosis; pyloroplasty	3
Disconnection of gastroenteric anastomosis	2
Disconnection of posterior gastroenteric anastomosis; anterior gastroenterostomy and entero-anastomosis	1
Total	17

In cases of impending fistula the patient is usually in better condition than in cases of fistula since nutritional disturbances have not been caused by the fistula. However, the gastrojejunal ulcer is usually so acute and the symptoms are so severe that the patients are not in good condition for extensive operation. In cases of impending fistula it is best to leave the base of the ulcer attached to the colon. The omentum may be sewed over the base of the ulcer for additional protection. Since there is no danger of fecal contamination, extensive surgical procedures can be carried out. Partial gastric resection was performed in eleven of the seventeen cases in our series. The immediate surgical mortality was 12 per cent as compared to a mortality of 32 per cent in cases in which a fistula had developed.

A gastroduodenal fistula that is secondary to a malignant lesion of the stomach or colon is rarely amenable to operative treatment. In most cases metastasis has occurred or the lesions are so extensive that they cannot be removed. The most satisfactory procedure when it can be performed is en bloc resection of the stomach and colon with restoration of gastrointestinal continuity, or resection

of the stomach and exteriorization of the involved portion of the colon.

## SUMMARY

Gastrojejunal ulcers and fistula present a most formidable surgical problem. They are a complication of gastrojejunal ulcer which occurred in about 3.2 per cent of cases in which gastroenterostomy was performed at the clinic. Gastrojejunal fistula occurs in about 14 per cent of cases of gastrojejunal ulcer and in about 0.5 per cent of cases in which gastroenterostomy is performed. Patients who have gastrojejunal ulcers should be operated upon before the ulcer perforates into the colon and a fistula occurs. Gastrojejunal fistula occurs almost exclusively among men; it usually affects men who are between 40 and 60 years of age. The surgical treatment of gastrojejunal fistula is difficult and hazardous, but it is imperative as soon as the condition of the patient can be improved sufficiently to warrant such a procedure. Surgical management should include not only closure of the fistula but also measures to control the ulcer-forming tendencies of the patient. Two-stage procedures are frequently advisable.

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IN most instances the inflammatory process in a crypt undoubtedly subsides spontaneously with no treatment. It is evident, however, that infection in the depths of the ducts extending from the crypt will not clear up so readily but may persist for a considerable period just as a gonorrheal infection, for example, will be harbored for a long time in the peri-urethral glands.

# OPERABILITY, MORBIDITY, AND MORTALITY FACTORS IN CARCINOMA OF THE COLON\*

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THE most frequent site of carcinoma in both sexes is the gastrointestinal tract and of all the malignant lesions involving this system, those of the large bowel offer the best prognosis. According to Lord Moynihan<sup>1</sup> "few places in the body affected by carcinoma are so accessible and safe to curative operations." The relatively good prognosis in carcinoma of the colon is dependent upon several factors, significant of which are: (1) greater operability, (2) greater benignancy, and (3) increased life expectancy.

The operability of carcinoma of the colon varies considerably, but as compared with malignant lesions of the rest of the gastrointestinal tract is relatively high. In the reported statistics it varies from 38.5 per cent<sup>2</sup> to 81.3 per cent.<sup>3</sup> In a total series of 4,561 collected cases<sup>2-24</sup> of carcinoma of the large bowel, 2,670 (58.5 per cent) were operable. Rankin and Olson<sup>25</sup> state that the highest operability for carcinoma of the colon at the Mayo Clinic was 68 per cent. Of the twenty-three different reports concerning operability, fifteen (65.2 per cent)<sup>3,5-7,10-12,14-17,20-22</sup> had an operability of 50 per cent or better, and eight (34.7 per cent)<sup>2,4,8,9,13,18,19,23</sup> an operability less than 50 per cent. Koch<sup>18</sup> found that 51 per cent of right-sided lesions were resectable and only 35 per cent of left-sided tumors could be removed. Dixon<sup>26</sup> states that about 50 per cent of cecal carcinomas can be completely removed. Jacobson<sup>10</sup> observed that 75 per cent of right-sided lesions, 80 per cent of the transverse colon lesions, 63 per cent of the splenic flexure and descending colon lesions, and only 30 per cent of sigmoid tumors were operable. The

low incidence of operability of sigmoid lesions was due to their late recognition. Geschickter<sup>16</sup> found that of 250 cases of carcinoma of the colon the operability was as follows: ascending colon (seventy-five cases) 53 per cent, hepatic flexure (fifteen cases) 85 per cent, splenic flexure (twelve cases) 45 per cent, and descending colon (eighty-five cases) 47 per cent.

Jacobson<sup>10</sup> reports the following operability according to ages: from 20 to 30 years, 50 per cent; from 30 to 40, 100 per cent; from 41 to 50 years, 57 per cent; from 51 to 60, 61.5 per cent; from 61 to 70, 58.8 per cent, and from 71 to 80, 25 per cent. Jordan<sup>27</sup> found that the incidence of operability at the two extremes of life was not so great as in the intervening periods. Whereas from 21 to 30 years and from 71 to 80 years the operability was only 40 per cent, from 31 to 40 and from 41 to 50 it was 80 per cent and 60 per cent, respectively.

The operability of cancer of the colon is further illustrated by the autopsy statistics of Larson,<sup>28</sup> Harding and Hankins.<sup>29</sup> The first author<sup>28</sup> found that of 210 cases of carcinoma of the colon coming to autopsy, 113 had either no metastases at all or only a few small regional glands which were resectable. Harding and Hankins,<sup>29</sup> in 118 post-mortem examinations, found no apparent metastases in 41 per cent and in an additional 4 per cent the metastases were readily amenable to surgical extirpation. It is thus evident that in 44 per cent of this group of fatal cases lesions were resectable. It is of interest that of thirty-five cases in which palliative operations were performed in this group, twenty were found to be resectable.

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Undoubtedly, in many instances cases are erroneously considered inoperable at the time of exploration because of the size and fixation of the lesion. Whereas the appearance of the tumor and its fixation may suggest only neoplastic growth, not infrequently much of this process is actually inflammatory. We have repeatedly observed that complete deviation of the fecal stream away from the involved segment results in regression in the tumor and return of bowel mobility. This can be accomplished best by the defunctionalizing operation.<sup>30-34</sup> As the result of this procedure there occurs, in addition to the local improvement in the lesion, general improvement of the patient. As we previously stated,<sup>33,34</sup> the operability is greatly increased not only because of decreased size and diminished fixation, but also because more extensive resections are possible.

The mortality rate following extirpation of carcinoma of the colon is, as might be expected, relatively high because extirpation of the colon entails considerable risk. It varies considerably in different hands and is undoubtedly dependent upon the time at which the diagnosis is made, the extent and the malignancy of the lesion, the preoperative preparation, and the type of operation performed. In the hands of most surgeons, radical resection of the colon for carcinoma gives a mortality rate of approximately 20 per cent. In a series of 2,991 collected cases<sup>2-5,7,9,10,12-15,18-20,22,23,24,35-43</sup> in which resection of the colon was done for malignancy, there were 422 (21.7 per cent) deaths. The lowest reported mortality rate is that of Haggard,<sup>37</sup> 3.1 per cent in a series of thirty-two cases and the highest, 63 per cent, reported by Adams<sup>2</sup> in a series of twenty-seven cases. Of the twenty-six reports, the mortality rate was less than 20 per cent in ten (34.6 per cent).<sup>4,7,13,15,18,20,36-38,41</sup> It is of significance that Rankin<sup>38</sup> had 493 cases with only sixty-eight deaths (13.7 per cent). Jones<sup>41</sup> had a remarkably low mortality rate, reporting 161 cases with sixteen deaths (10.5 per cent). According to

Fowler,<sup>44</sup> the mortality rate is high under 26 years of age, approximately 50 per cent. Finsterer<sup>20</sup> had seven deaths in thirty-five cases in the seventh decade, four in twenty-five cases in the eighth decade, and one in three cases in the ninth decade. In MacFee's<sup>23</sup> cases, the highest mortality rate (27.9 per cent) followed the exteriorization operation in sixty-eight cases, and the lowest mortality rate (16.1 per cent) followed an aseptic anastomosis in fifty-six cases. In thirty-two cases in which open suture was performed, there were six deaths (18.8 per cent).

Generally, resections of the right colon are considered safer than resections of the left colon. In ninety-one cases of right-sided colectomy reported by Allen,<sup>42</sup> seventeen (18.6 per cent) died, whereas of 169 cases of left-sided resection, thirty-nine (23.8 per cent) died. Paus'<sup>12</sup> mortality in right-sided colectomies was 17.1 per cent, as contrasted with 31.1 per cent in left-sided colectomies. Rankin<sup>38</sup> had 160 cases with right-sided colectomies with fourteen deaths (8.7 per cent) and 333 cases with left-sided colectomies with fifty-four deaths (16.2 per cent). Rosser,<sup>45</sup> on the other hand, had mortality rates of 52 per cent following right-sided and 22 per cent following left-sided colectomies. The respective mortality rates following resection of the midcolon were 33 per cent and 20.4 per cent in Rosser's<sup>45</sup> and Mayo and Simpson's<sup>24</sup> series.

The life expectancy following resection of the colon for carcinoma varies considerably in different statistics. Generally speaking, the outlook following the adequate removal of carcinoma of the colon is relatively good. Of a series of 3,911<sup>3,5,7,9,11,12,14,15,18-21,23,46,47</sup> reported resections for carcinoma of the colon there were 1,204 (30.7 per cent) five-year cures. The highest incidence of five-year cures was obtained by Oughterson and Shelton<sup>11</sup> (52.6 per cent) in a series of 131 cases. Of those patients who survived three years, 72.7 per cent were still alive at the time of their report. Rankin<sup>46</sup> in a series of 753 cases had five-year cures in 45.8 per cent.

Pemberton and Dixon,<sup>47</sup> in a series of 1,920 resections of colon performed at the Mayo Clinic, had five-year cures in 22.2 per cent. Seven of the fifteen reports<sup>9,11,12,18,20,21,46</sup> had five-year cures ranging from 40.8 per cent of 52.6 per cent. Dixon and Olson<sup>48</sup> reported twelve patients who lived twenty years or longer following a resection for carcinoma of the bowel. According to Martin,<sup>49</sup> right-sided lesions give a better prognosis than left, as regards length of life. He states that if the tumor is adequately removed the patient is likely to have freedom from recurrence from four to eight years. Dixon<sup>26</sup> states that 56 per cent of all patients who have had resection of the cecum for carcinoma are well five years or more. If one includes those cases in which there are no nodes, the incidence of a five-year cure is 62 per cent. Geschickter<sup>16</sup> reported 20 per cent cures for carcinoma of the ascending colon, 21 per cent cures for the hepatic flexure, no cures for the splenic flexure, and 20 per cent cures for the descending colon. The percentages of five-year cures according to location in Pemberton and Dixon's<sup>47</sup> series were as follows: cecum 51.8 per cent; transverse colon, 48.9 per cent; descending colon, 40.6 per cent; and sigmoid, 36.9 per cent. Whereas the incidence of five-year cures following resection of the colon for carcinoma is relatively high, the prognosis even in these cases should be guarded as demonstrated by the statistics of Paus<sup>12</sup> and Abell.<sup>9</sup> The former found that whereas 48.4 per cent of patients subject to radical resection were free from recurrence five years postoperatively, only 30.7 per cent were free from recurrence at the end of ten years. Of twenty-five patients surviving radical resection reported by Abell, sixteen (64 per cent) were living at the end of five years but only six (24 per cent) living ten years or longer.

The outlook in intestinal cancer has become more favorable in the past decade, but it still remains far from ideal. This is influenced by a number of factors which can be classified in two large groups: (1)

uncontrollable, and (2) controllable. Although the factors in the former group (uncontrollable) are of significance from academic and prognostic viewpoints, they are of little therapeutic value. The controllable factors, on the other hand, are of importance, from both standpoints. Thus, they influence prognosis and determine the type of therapy. These factors may be classified as follows:

- I. Uncontrollable
    - A. Age
    - B. Lesion
      1. Type
        - (a) Macroscopic characteristics
          - (1) Cicatrizing
          - (2) Ulcerative
          - (3) Fungating
          - (4) Polypoid
        - (b) Microscopic characteristics
          - (1) Grading
          - (2) Histologic types
            - (a) Adenocarcinomatous
            - (b) Scirrhus
            - (c) Medullary
            - (d) Colloidal
    2. Extension
      - (a) Local
        - (1) Mural
        - (2) Extramural
      - (b) Distant
        - (1) Lymph nodes
        - (2) Liver
    3. Location
      - (a) Right half of colon
      - (b) Left half of colon
    4. Multiple
  - C. Associated disease
- II. Controllable
  - A. Duration
  - B. Preoperative and postoperative management
    1. Decompression
      - (a) Nonoperative
      - (b) Operative (colostomy)
        - (1) Simple
        - (2) Defunctionating
    2. Hydration

3. Vitamin and protein administration
4. Transfusion
5. Peritoneal vaccination
- C. Anesthesia
- D. Operative management
  1. Single stage procedure
  2. Multiple stage procedure
  3. Restorative procedures
- E. Complications
  1. Peritonitis
  2. Pulmonary

Carcinoma of the large bowel is a disease largely of advancing age and differs from carcinoma of the rectum in that in the former older individuals are more frequently involved. Approximately three-fourths of the former cases occur in the fifth, sixth, and seventh decades. Whereas it may seem that this advanced age might indicate a poor prognosis, actually statistics demonstrate that the prognosis in the older patients with carcinoma of the colon is not particularly bad. Adams<sup>2</sup> states that the older the patient, the more localized is the lesion. Finsterer<sup>22</sup> believes that no patient with colonic cancer is too old or too weak to be operated upon. In seventy-six of his cases in which a radical operation was done, thirty-four (44.7 per cent) were over 60 years of age; nineteen were between 71 and 80, and two were over 80 years of age. Finsterer<sup>50</sup> found that of eighty-six cases under 60 years, 20.9 per cent died; of fifty-four between 60 and 69, 25.9 per cent died, and of five between 80 and 86, 20 per cent died. It is thus obvious that increasing age is not necessarily a significant factor in prognosis. In fact, in the presence of acute ileus in Finsterer's<sup>50</sup> cases, the older patients had a lower mortality rate than those under 60. According to Larson,<sup>28</sup> a patient 60 years of age who has a malignant lesion of the colon has a much better operability chance than one 50 years of age, other factors being equal. Shedden<sup>51</sup> collected thirty-six cases of carcinoma of the colon and rectum in patients less than 12 years of age, of which twenty were in the rectum. Only one of the

entire group was known to have lived as long as two years, at which time he died. The poorer prognosis in young individuals with carcinoma of the colon is undoubtedly due to the fact that the lesion in younger individuals is of a more immature type and therefore more malignant. This is borne out by the findings in Rankin and Broders'<sup>52</sup> cases of carcinoma of the rectum. In a series of patients aged 30 years or less, the tumors belonged to grades 3 and 4 in over half (52 per cent) of the cases, in contradistinction to a series of patients of all ages in which less than one-third (31 per cent) of the lesions were in these grades. Rankin and Graham<sup>53</sup> believe that with advancing age, metastases are less likely to occur because of atrophy of the lymphatic structures. It is evident that whereas advancing age in a patient with cancer of the colon increases the operative risk, the lower grade of malignancy in such an individual, prognostically at least, balances and may even outweigh the disadvantages of the former factor.

Of great importance from a prognostic standpoint is the type of tumor in the bowel, because the degree of malignancy varies according to the gross and microscopic characteristics of the lesion. Carcinomas of the large bowel may be classified as adenocarcinomas, medullary carcinomas, mucoid (colloid) carcinomas, and scirrhous carcinomas. Of these, the medullary and mucoid carcinomas offer a poorer prognosis than do the adeno- and scirrhous carcinomas. In Raiford's<sup>19</sup> series, the incidence of five-year cures varied according to these types as follows: cellular or medullary carcinoma, none; primary mucoid carcinoma, none; adenocarcinoma, grade 4, 20 per cent, grade 3, 22.2 per cent, grade 2, 24 per cent, grade 1, 43 per cent; adenocarcinoma with mucoid degeneration, 34.8 per cent; and scirrhous carcinoma, 50 per cent. Rankin and Olson<sup>25</sup> contrasted the results obtained in forty-four cases of mucoid carcinoma with 409 cases of non-mucoid carcinoma. They found that 10 per cent of the entire group of cases were of the

muroid type. The average postoperative period of life in months in the patients who developed recurrences was 17.6 per cent for the muroid carcinomas and 26.8 per cent for the non-muroid group. The percentages of five-year cures for the former was 48, whereas for the latter it was 52. The relatively greater degree of malignancy of colloid carcinomas is illustrated by Hayes<sup>54</sup> studies. In a series of 100 cases of carcinoma of the large bowel, eight were of colloid type. Of ninety-five involved lymph nodes in the entire series, thirty-nine (41 per cent) occurred in patients with colloid carcinomas. Thus 41 per cent of the entire lymph gland involvement occurred in only 8 per cent of all the cases; the colloid carcinoma group. Harding and Hankins<sup>29</sup> found in autopsy series that 87.7 per cent of 118 cases of carcinoma of the large bowel were of the broad medullary ulcerating or the fibrocarcinomatous (scirrhous) types. Forty-three per cent had no evidence of metastases even though the patients had died of the disease. Twelve per cent of the entire group were of the gelatinous, bulky type, and 50 per cent of these had perforated with the production of peritonitis.

Karsner and Clark<sup>55</sup> found that of the seventeen cases of carcinoma of the sigmoid, 82 per cent were annular. Of twenty-three involving the upper colon, 61 per cent were annular, and of seven in the cecum, none were annular. These figures of Karsner and Clark are particularly significant when one considers that a cicatrizing lesion in the sigmoid is of much more importance than a similar lesion in the cecum, because the fecal contents of the former are solid and obstruction is much more likely to occur. Raiford<sup>19</sup> found that of forty cases of carcinoma of the cecum, two; of eleven involving the transverse colon, one; of nine involving the splenic flexure, one; and of thirty-three involving the descending colon and the sigmoid, seven were of the scirrhous types. The gross type of lesion is also of significance prognostically, because a fungating tumor, particularly of the colloid

variety, is likely to be accompanied by severe secondary anemia, whereas the scirrhous type is less frequently associated with anemia, but is more likely to be complicated by obstruction.

Rankin and Olson<sup>25</sup> found that the size of the original lesion was of little prognostic significance in resectable carcinomas. In the patients who died from recurrence following resection, the original tumor measured on an average less than 0.2 cm. greater than those that survived. Generally, they found that right-sided growths, particularly those in the cecum, were larger. The average sizes of tumors of the cecum, right colon, left colon, and sigmoid in the fatal cases with recurrence were 7.7 cm., 7.1 cm., 6.2 cm., and 5 cm., respectively. Of a similar group of cases which survived and were apparently cured, the average sizes were 7 cm., 7.2 cm., 5.7 cm., and 5.4 cm., respectively. Rankin and Olson state, "It has been noted that those malignant growths which project into the lumen give a better result than those in which the predominant direction of growth is toward the serosa." This statement is verified by Craig,<sup>56</sup> who found that of the malignant lesions of the cecum without local metastases, tumors usually protrude into the lumen and invade the wall relatively little. He found that the most frequent site for cancer of the cecum is the posterior wall which influences the prognosis in that lesions in this location are more likely to metastasize early to the regional lymph nodes which are situated posteriorly.

Of great prognostic value is the type of malignant cell. The more immature the cell, the greater the degree of malignancy and the poorer the prognosis. Broders<sup>57</sup> has emphasized the importance of grading carcinomas in various portions of the body by histologic examination. In such a way it is possible for the pathologist to prognosticate within limits in individual cases. Rankin,<sup>46</sup> in a series of 853 cases of colonic carcinoma, found that the incidences of the various grades were: grade 1, 12.9 per cent; grade 2, 57 per cent; grade 3, 21.3 per cent;



and grade 4, 8.79 per cent. In the same series of cases the incidence of five-year cures in those whose tumors were graded 1 and 2 was 49.6 per cent, whereas only 26.4 per cent of those whose tumors were graded 3 and 4 survived five years. Of the five-year cures, 81.4 per cent had lesions belonging to grades 1 and 2 and only 18.6 per cent had lesions graded 3 and 4. The effect of the degree of malignancy on the life expectancy and cures is illustrated further by Rankin and Olson's<sup>25</sup> statistics. In a series of 453 cases of carcinoma of the colon, there were sixty-five in group 1 with 64.6 per cent five-year cures; 277 in group 2 with 54.5 per cent five-year cures; eighty-one in group 3 with 38.2 per cent five-year cures; and thirty in group 4 with 30 per cent five-year cures. This definitely shows the value of malignancy grading and also shows that most of the tumors of the colon are relatively benign. Of the 453 cases, 342 were in groups 1 and 2 (75.4 per cent). Dixon and Olson<sup>48</sup> found that of 453 cases of carcinoma of the colon, 14 per cent were in grade 1, 61 per cent in grade 2, 18 per cent in grade 3, and 7 per cent in grade 4. Of a group of cases with twenty-year cures following removal of carcinoma of the large bowel, 50 per cent were in grade 1. These same authors found that the five-year survivals in the 453 cases were as follows: grade 1, 66 per cent; grade 2, 54 per cent; grade 3, 38 per cent; and grade 4, 30 per cent. Dixon and Olson also found that in these cases metastases occurred twice as frequently from carcinomas of grade 4 as from those of grade 1. These statistics substantiate the statement made above concerning the relative benignancy of colonic carcinomas because even in the higher grades (3 and 4) the incidence of five-year cures is relatively high.

Extension of a malignant lesion in the large bowel can occur by direct invasion and through the lymphatic and blood streams. Lesions remain localized in the bowel wall for relatively long periods of time, but, as emphasized by Felsen,<sup>58</sup> once the neoplastic process has invaded the

submucosa, the lymphatics are likely to become involved. This author describes two ways in which lymphatic extension can occur in the bowel wall: (1) by annular extension involving the large, circular intramuscular plexus; and (2) by wedge-shaped extension to the peritoneum. In twenty-one of 118 cases of carcinoma of the large bowel reported by Harding and Hankins,<sup>29</sup> the growth had extended through the bowel wall with resulting perforation. Raiford<sup>19</sup> found, in 190 cases of carcinoma of the colon, forty-seven (24.8 per cent) had metastases to the lymph nodes, seventeen had metastases to the liver (8.9 per cent), and nineteen (10 per cent) had metastases to other locations. Hayes<sup>54</sup> in a series of carcinomas of the colon which he examined particularly with reference to lymph gland involvement, found that 63 per cent had no lymph gland involvement and that the size of the tumor had no relation to the presence or absence of metastases, because twelve of the sixty-three cases with no lymph gland involvement had extensive tumors in the bowel which encircled the lumen. There were thirty-seven cases (37 per cent) with metastases, nine of which had encircling growths. Hayes<sup>54</sup> found that in those cases in which metastases occurred there was usually extension to the nearest lymph node, but occasionally the nodes nearest the tumor were inflammatory, and the more distant nodes were carcinomatous. It is of interest that in the group of cases studied by Hayes, there were eight with colloid carcinoma in which there were metastatic lesions. Of all the involved nodes in the entire group of 100 cases, 41 per cent were found in the group with colloid carcinoma. Equally as important is the fact that 26.3 per cent of the total number of recurrences which occurred during the year and a half period were in this group of 8 per cent of cases in which there was a colloid carcinoma with metastases. Broders<sup>59</sup> states that a colloid carcinoma which has once metastasized is extremely difficult to control.

Craig and MacCarty<sup>56</sup> studied 100 cases of carcinoma of the cecum with special reference to lymph gland involvement and found that 68 per cent were without metastatic involvement and that 32 per cent had involvement of the regional lymph nodes. Of the 100 cases there were twenty with colloid carcinoma. Twelve of these twenty (60 per cent) had metastases to the regional lymph nodes. Of the eighty cases which were not of the colloid group, only 25 per cent had lymph node metastases. It is evident therefore that regional lymphatic extension is approximately two and a half times more likely to occur in colloid carcinoma of the cecum than in the noncolloid types. Harding and Hankins<sup>29</sup> in twelve cases of colloid carcinoma observed metastases in 50 per cent.

The incidence of glandular metastases according to the grading of the carcinoma is of value and interest. Of 753 cases reported by Rankin,<sup>46</sup> grade 1 tumors had glandular involvement in 27 per cent, grade 2, in 35 per cent; grade 3, in 50 per cent; and grade 4 in 56 per cent. Rankin states that a grade 1 cancer without malignant glands has four and a half times better prognosis than a grade 4 carcinoma with malignant glands. Harding and Hankins<sup>29</sup> observed metastases in 56 per cent of the medullary tumors, 22 per cent of the scirrhous and 50 per cent of the gelatinous tumors. Of their entire group of cases the liver was involved in 39 per cent. Of the cases of scirrhous carcinoma, 34 per cent had metastases to the liver. In a series of 190 cases reported by Raiford,<sup>19</sup> seventeen (8.9 per cent) had hepatic metastases. In Harding and Hankin's<sup>29</sup> cases, the lungs and peritoneum were involved in 24 per cent. Paus<sup>12</sup> found that 20 per cent of 206 cases had encroachment upon the neighboring organs. There were metastases in over half the autopsy cases and 25 per cent of the operative cases. The metastases were most often to the lymph nodes and next to the liver and peritoneum.

As has been emphasized by Rankin<sup>60</sup> and others, the prognosis in malignancies of the

colon is greatly dependent upon the location of the tumor. Rankin has shown that the prognosis in right-sided colonic carcinomas is much better than in left-sided carcinomas. He has emphasized that metastases occur later in the former lesion than in the latter due to the scanty lymph drainage on the right side as compared with the left. He and Olson<sup>25</sup> showed that right-sided lesions were larger than left-sided ones, probably due to the fact that the fluid contents of the right colon resulted in obstruction relatively late and the patient's attention was not directed to the malignancy. They compared the size of the lesion in a group of patients who recovered over a five-year period of time with the patients who died. These were as follows: of the fatal cases involving the cecum, the average size was 7.7 cm.; the right colon, 7.1 cm.; the left colon, 6.2 cm.; and the sigmoid, 5 cm. In a similar group of cases in which a five-year cure was obtained, the average size in the cecum was 7 cm.; the right colon, 7.2 cm.; the left colon, 5.7 cm.; and the sigmoid, 5.4 cm. According to these figures, it is evident that the size of the neoplasm is of little significance as regards prognosis because of the inconsistent differences in the size of the tumors between the fatal cases and those which recovered. However, of interest is the inconsistent decrease in size of the tumor from the cecum aborally. In this same series of 187 cases involving the right colon and cecum, there were 106 (57.6 per cent) five-year cures. In a series of 266 cases involving the left half of the colon and the sigmoid there were 127 (47.7 per cent) five-year cures. It can thus be seen that in this group of cases the incidence of five-year cures was approximately 10 per cent better on the right side than on the left. Rankin, in another publication,<sup>46</sup> showed that the incidence of five-year cures was 39 per cent in 187 cases of carcinoma of the right colon, of which 34 per cent had nodal involvement. Sixty-six per cent of those without nodal involvement had five-year cures. In the left colon in a series of

266 cases, 31 per cent had nodal involvement. Of this group, there were 29 per cent five-year cures. The incidence of five-year cures in those involving the left colon without nodal involvement was 56 per cent. This again illustrates that prognosis is much better in right-sided lesions, both in those patients without as well as with nodal involvement, the incidence of five-year cures being about 10 per cent greater in both groups.

Pemberton and Dixon,<sup>47</sup> in a series of 1,920 cases of carcinoma of the colon, found that the incidence of five-year cures was as follows: in the cecum, 51.8 per cent; in the remaining portions of the colon down to the sigmoid, 48.9 per cent; the sigmoid, 40.67 per cent; and the rectosigmoid, 36.9 per cent. It is thus seen that the incidence of five-year cures decreases proportionately with the distance from the cecum to the rectum. Left-sided malignancies are of importance and offer a poorer prognosis, everything else being equal, because of the greater likelihood of obstruction on the left side. This is due to the fact that the left-sided lesions are more likely to be stenosing. Of equal importance is the fact that the contents of the left side of the colon are solid, whereas those on the right are fluid. Burgess<sup>61</sup> described 480 cases of colonic carcinoma, of which 35.6 per cent had acute obstruction. Of those with acute obstruction, 13.2 per cent were on the right side and 86.7 per cent on the left. Koch<sup>18</sup> observed an ileus in 23.6 per cent of right-sided lesions and in 37.1 per cent of left-sided lesions. Alvarez, et al.<sup>62</sup> emphasized the likelihood of a larger lesion on the right side as compared with the left. They found that the average surface area of cecal lesions was 51.6 sq. cm. and that of the sigmoid lesions 31.2. Geschickter<sup>16</sup> showed that cures as well as the operability were greater in right-sided lesions than in left-sided ones. In a series of ninety right-sided lesions, 58.8 per cent were operable, of which 20 per cent were cured. In ninety-seven left-sided lesions, 46.8 per cent were operable, of which 17.5 per cent were cured.

Geschickter also states that over 50 per cent of carcinomas of the ascending colon and cecum are operable and that 40 per cent of the patients are well after five years. Less than 50 per cent of those with hepatic and splenic flexure lesions are operable, and 10 per cent are well after five years. About 85 per cent of the transverse colon lesions are operable, and 25 per cent are well after five years. The reason there was not a higher incidence of cures in the transverse colon lesions was because of involvement of the stomach. Approximately 50 per cent of descending colon and sigmoidal carcinomas are resectable, and 40 per cent are well after five years. Jacobson<sup>10</sup> has likewise shown that the operability varies according to the location of the lesion. Seventy-five per cent of right sided lesions, 80 per cent of transverse colon lesions, 63 per cent of splenic flexure and descending colon lesions, and 30 per cent of sigmoidal lesions are operable. Koch<sup>18</sup> found that 51 per cent of right-sided lesions were resectable whereas only 35 per cent of left-sided ones were resectable. Of 100 right-sided colonic lesions MacFee<sup>23</sup> found 50 per cent resectable and of 180 left-sided lesions, 54.4 per cent resectable. Mayo and Hendricks<sup>63</sup> have emphasized that carcinoma of the right bowel involves the liver relatively infrequently, whereas carcinoma of the left bowel involves the liver earlier and more frequently because of trauma of the hard feces.

It has been well known that anemia is likely to be a prominent manifestation in right-sided lesions. Alvarez et al.,<sup>62</sup> Karsner and Clark<sup>55</sup> believe that the reason for the greater incidence of anemia in right-sided lesions than in left is that a much larger ulcer is likely to occur on the former side.

In a collected series of 718 cases of carcinoma of the colon,<sup>3,5,7,20,42</sup> the right colon was involved in 285 and the left in 433. The average mortality rate following resection of the right-sided lesions was 19.6 per cent whereas that following resection of the left colon was 24.4 per cent. Crafoord,<sup>3</sup> in a series of ascending colon

carcinomas, had a mortality of 18 per cent; of the transverse colon, 29 per cent; of the descending colon, 37 per cent; and of the sigmoid and rectosigmoid, 42 per cent. Paus<sup>12</sup> obtained a mortality rate of 17.1 per cent in right-sided lesions and 31.1 per cent in left-sided lesions. Söderlund<sup>14</sup> reported eighty-two cases of resection of the colon, in which there were twenty-eight ileocecal resections with five deaths (18 per cent) and fifty-four resections of the transverse and left colon with fifteen deaths (28 per cent). In contradistinction to the reports<sup>3,5,7,12,14,20,42</sup> in which there were lower mortality rates following the resection of right-sided lesions than following left-sided colectomy, is that of Rosser<sup>45</sup> who reported a mortality rate of 52 per cent in right-sided lesions; 33 $\frac{1}{3}$  per cent in midcolon; 22 per cent in left-sided lesions; and 27 per cent in the rectosigmoid.

In the colon as elsewhere, multiple malignant lesions can occur. They influence prognosis, in that, over-looked lesions following the resection of one may cause the death of the individual because of the continued growth of the undetected neoplasm. Of eighty-seven cases of cancer of the colon treated by Abell,<sup>9</sup> there were two with malignant lesions in both the cecum and transverse colon. Warren and Gates<sup>64</sup> collected twenty cases with multiple malignant lesions in the colon, exclusive of the rectum. They state that the incidence of multiple malignant lesions occurring anywhere in the body is 1.8 per cent. In the gastrointestinal tract multiple malignant lesions occur most frequently in the colon and rectum. Hurt and Broders<sup>65</sup> found that of 2,124 malignant lesions, there were six multiple primary lesions in the large bowel. Brindley,<sup>66</sup> in 119 cases in which the tumor was in the colon, found two with multiple primary lesions (1.6 per cent). Miller<sup>5</sup> had 129 cases of cancer of the colon of which four were multiple lesions. Paus<sup>12</sup> in a series of 206 autopsy cases of carcinoma of the colon had seven (3.4 per cent) with multiple growths and of 571 clinical cases there were two (.35 per cent). The largest

series of multiple lesions of the large bowel (sixteen) has been reported by Barga and Rankin.<sup>67</sup> They suggest that the polypi may be a factor in the production of multiple lesions. Cokkinis<sup>68</sup> observed four cases of multiple growths in fifty-four cases of cancer of the colon. At that time (1934), he was able to find only twenty-nine recorded authentic cases of multiple lesions of the large bowel, in three of which the lesion occurred below a colostomy and was probably independent of the primary growth. Mayo and Zellhoefer<sup>70,71</sup> reported two cases with simultaneous lesions in the colon and sigmoid. Klingenstein<sup>72</sup> reports a case of cancer of the transverse colon which was resected. Five years later, a cancer of the sigmoid colon was resected; three years later the uterus was resected for carcinoma; and six years later cancer of the descending colon was successfully removed. According to Norbury,<sup>73</sup> the prognosis following an operation for a malignant lesion of the colon is dependent upon the presence or absence of other lesions such as polypi because if left behind the danger of recurrence is relatively high.

Carcinoma of the colon is not infrequently associated with chronic inflammatory lesions involving the bowel. Reed and Anderson<sup>74</sup> report four cases in which carcinoma followed a long continued infection with *E. histolytica*. Barga<sup>75</sup> reports nineteen cases of carcinoma of the colon associated with chronic ulcerative colitis. All of these lesions were resected and none of the patients were living at the time of his report. Barga and Dixon<sup>76</sup> report twenty-three cases of carcinoma of the colon associated with chronic ulcerative colitis. In eight cases in which two-stage resections were done by Dixon, there were seven recoveries. As suggested by Reed and Anderson,<sup>74</sup> the persistence of the infection may be a factor in the development of the carcinoma as the result of chronic irritation or the associated pseudopolypi which follow the persistent infection. Miller<sup>77</sup> reports a case in which a tuberculous lesion of the

descending colon had a carcinoma grafted upon it.

Obesity associated with carcinoma of the colon is of prognostic significance. An operative procedure is much more difficult in obese individuals and the incidence of infection is greater and of much more serious nature when it occurs.

While the factors discussed above are of great prognostic importance, from a therapeutic standpoint they are of little significance because they are uncontrollable. On the other hand, there are certain factors which are not only of prognostic importance but also of therapeutic value because, being controllable, they can be made to influence the outcome.

Carcinoma of the colon is relatively slow growing and patients are likely to have symptoms for a long time before resorting to radical therapy. Jordan<sup>27</sup> states that of 270 patients with carcinoma of the colon, sixty-nine had symptoms for six months; fifty-two for a year, and thirty-one two years and longer. In a series of fatal cases studied by Karsner and Clark,<sup>35</sup> the duration of symptoms ranged from ten days to forty-eight months, the average being 10.2 months. The average duration of symptoms in those lesions involving the splenic and hepatic flexures was 12.9 months, although for the rest of the colon the average duration was 9.8 months.

Oughterson and Shelton<sup>11</sup> state that 78 per cent of their patients were admitted to the hospital within one year after the onset of symptoms and that 73.4 per cent visited their doctor within three months of the onset. On the basis of their study they believe that the length of time elapsing between the onset of symptoms and admission to the hospital is becoming less.

The duration of symptoms is approximately ten to ten and one-half months according to Rankin,<sup>46</sup> Rosser,<sup>45</sup> and Finsterer.<sup>22</sup> In Rosser's<sup>45</sup> series of cases the duration varied from two months to two years. Adams<sup>2</sup> states that 70 per cent of cases had an average duration of symptoms of eighteen months. The duration of

symptoms was longer in left-sided lesions than in right-sided ones. Fifty-six per cent of Lahey's<sup>78</sup> 155 cases had symptoms for six months or less and 85 per cent had symptoms for less than one year. In 129 cases reported by Miller<sup>6</sup> the average duration of symptoms was sixteen months. In 290 cases reported by Cattell<sup>79</sup> the average duration was twelve months. According to Miles,<sup>80</sup> approximately one year is required for a rectal carcinoma to invade the wall of the bowel for about three-fourths of its circumference and that eighteen months are required for complete encirclement of the bowel.

In carcinoma of the colon as elsewhere, the prognosis, everything else being equal, is better the shorter the duration of the symptoms. Obviously, complete extirpation of the lesion can be more readily accomplished if extension beyond the bowel has not occurred. The diagnosis of malignant lesions of the bowel is relatively easy, provided its possibility is always considered.

The prognosis in carcinoma of the colon is greatly dependent upon the presence or absence of obstruction. Generally a patient with a carcinoma of the colon without obstruction has a much better prognosis, irrespective of the type of therapy, than a similar patient with obstruction. In a series of thirty-four cases of carcinoma of the colon admitted to Finsterer's<sup>20</sup> service with acute obstruction, ten died (29.4 per cent). In a similar series of sixty-one cases without obstruction, only nine (14.7 per cent) died. Obstruction associated with carcinoma of the bowel is dangerous to the individual because of a number of factors. It is our opinion that absorption of toxic products occurs in acute obstruction and that a similar although less severe process is operative in chronic obstruction. In addition to this, however, there are much more definite changes, particularly those in the bowel. Proximal to the obstruction there is marked hypertrophy, inflammation, diminished blood supply, and edema of the bowel wall. Herrmann<sup>81</sup> showed that in

the presence of obstruction the permeability of the bowel wall is greatly increased permitting the extravasation of the infective organisms into the pericolic tissues, thus predisposing to peritonitis, particularly when the bowel is manipulated. Equally as important also is the fact that the material contained within the bowel proximal to the point of obstruction is much more highly infective than that found in the normal bowel. It has long been known that the contents of an obstructed loop are much more toxic than the contents of a normal loop of bowel. This is undoubtedly due to the fact that in the presence of stasis, organisms have a greater opportunity for growth than in the absence of stasis. Rankin<sup>82</sup> states that between 75 and 80 per cent of patients with colonic carcinoma have obstruction at the time they consult a surgeon. Of Graham's<sup>17</sup> thirty-three cases of sigmoidal carcinoma, seventeen (50 per cent) were admitted with acute obstruction.

Little can be done in lowering the incidence of obstruction in colonic carcinoma, except by education of the laity and the practicing physician, but the surgeon is able to do a great deal in these cases by the institution of appropriate therapy. In the presence of obstruction, which unfortunately occurs far more frequently than it should, it is imperative that decompression of the obstructed bowel be done before any radical operative procedure is contemplated. This statement is confirmed by the results of all who have had any experience with the treatment of colonic carcinoma. Of thirty-one cases of carcinoma of the colon in which a radical resection was done with preliminary colostomy in Cheever's<sup>4</sup> series, only three (9.6 per cent) died. Of forty-seven cases in which resections were done without a preliminary colostomy, twelve (25.5 per cent) died. One year later, Cheever<sup>36</sup> reported another group of cases with similar results, i.e., 8.5 per cent mortality in cases with preliminary colostomy and 24 per cent without preliminary colostomy. Crafoord<sup>3</sup>

reported forty-four cases operated upon with obstruction of which nineteen (43 per cent) died. Of seventy-seven resected with a preliminary colostomy only twenty-two (29 per cent) died. Finsterer<sup>22</sup> reports that of forty-three cases of colonic carcinoma resected in the presence of acute ileus, thirteen (30.2 per cent) died and of 136 in which resection was done without acute ileus, twenty-seven (19.8 per cent) died. Of five cases of acute ileus treated by one-stage resection four (80 per cent) died. Of nine cases of acute ileus treated by two-stage resection, only one (11.9 per cent) died. Of twenty-three cases of acute ileus treated by three-stage resection, three (13 per cent) died. According to Gordon-Watson<sup>40</sup> a preliminary colostomy will reduce the mortality rate of approximately one-half. Roscoe Graham<sup>17</sup> had a mortality rate of 68 per cent when resection was done in the presence of obstruction, whereas following a colostomy the mortality rate dropped to 7.6 per cent. Von Haberer<sup>83</sup> reported 172 cases of one-stage resection without preliminary colostomy of which forty-five (25 per cent) died. Of 109 cases with colostomy and resection, twenty-two (20 per cent) died but only nine (8 per cent) died as a result of the operation; yet where the one-stage resection was done, most of the fatalities were from peritonitis. Paus<sup>12</sup> had a 16.3 per cent mortality rate following one-stage resection for carcinoma of the colon in the absence of obstruction and 32.3 per cent mortality rate following one-stage resection in the presence of chronic obstruction. This rose to 58.8 per cent in the presence of acute obstruction. The mortality rate following a one-stage resection was 29.8 per cent, whereas that following multiple stage resection was 15.7 per cent.

As most patients with carcinoma of the colon have some degree of obstruction (according to Rankin<sup>53</sup> approximately 75 per cent), the careful preoperative preparation of the patient is extremely important. In those cases in which there is not complete obstruction it is possible to decom-

press the bowel proximal to the obstruction by preoperative saline catharsis. It is a rule in our clinic to give a dram of magnesium sulfate every hour for six to eight doses. In this way, a small liquid stool is formed, which permits evacuation past the incompletely obstructed neoplastic lesion. This should be done several days before the contemplated operative procedure in order that the patient may be completely hydrated before operation. Obviously, it is necessary that the patient be placed on a non-residue diet after cleaning out the bowel. As left-sided lesions are more likely to become obstructed because of the cicatrizing nature of tumors on the left side and also because of the solid contents of the bowel on this side as contrasted with the right, preoperative preparation is particularly important. Even though preoperative preparation can be satisfactorily performed in left-sided lesions, a primary resection of left colon with immediate anastomosis should never be done. Always a decompressing fistula should be performed as a preliminary procedure. In right-sided lesions in the absence of obstruction, it is possible to perform a resection and primary anastomosis without preliminary deviation of the fecal stream, although, as advocated by Allen<sup>42</sup> and Rankin,<sup>84</sup> it is probably preferable even to use the two-stage procedure in right-sided lesions.

Whereas most surgeons employ a simple decompressing fistula in the form of a cecostomy or colostomy as a preliminary procedure in cases of carcinoma of the bowel particularly on the left side in order to relieve the tension on the suture line during healing, more are beginning to appreciate the value of complete "defunctionalization" of the bowel segment. Cheever<sup>36</sup> found that of fourteen cases in which a temporary colostomy or cecostomy was done, in 50 per cent the colostomy failed to prevent fecal leakage at the anastomosis site, and that in 42.8 per cent it was necessary to close operatively the colostomy stoma. On the other hand, in

eight cases in which a permanent type of colostomy was performed, there were no leaks at the anastomosis and three of the colostomies healed by primary intention. Cheever therefore believes that if a decompression colostomy is done it should be of the permanent type. In previous communications,<sup>33,34</sup> we emphasized the importance of complete "defunctionalization" of the bowel and protection of the operative site against contamination. As previously stated,<sup>31</sup> as long as fecal contamination of a bowel segment occurs, there will be little decrease in the pathogenicity of the microorganisms within the intestine. Whereas a double barrel colostomy deviates a great part of the fecal stream, almost invariably some soiling of the distal segment occurs. Only by completely excluding this segment of bowel from fecal contamination can there be any material diminution in its bacterial content. A complete isolation of the openings of the proximal and distal segments will prevent the entrance of feces into this portion.

We have been using in left-sided colonic lesions the "defunctionalizing" colostomy suggested by Devine.<sup>30-32</sup> To this author belongs credit for emphasizing the "defunctionalization" and "debacterIALIZATION" produced by complete deviation of the fecal stream from the involved portion of bowel. Under such circumstances the safety of resection of a lesion of the bowel is assured, not only because of the decreased number or the absence of pathogenic bacteria but also because of return of normal blood supply and tone to the intestine, all of which are necessary for optimum healing. We<sup>34</sup> reported twenty-six cases in which the Devine type of colostomy was done. Ten had malignant lesions, with the tumors located in the sigmoid or rectosigmoid in all but one instance, in which case it was situated in the splenic flexure. Six had resection of the bowel segment, three were found to be inoperable at the second operation so that the "defunctionalizing" colostomy was left as a permanent one, and one died fol-

lowing the colostomy. Of the six cases in which extirpation of the malignant lesion was accomplished, there was return of normal bowel function except in two cases in which extirpation of the rectum obviated reestablishing bowel continuity. None of the patients developed peritonitis.

It is important after cleansing the bowel by means of saline catharsis to reestablish the water balance before operation. This is also true in those patients on whom a preliminary decompressive operation has been done, particularly if the decompression is on the right side of the colon as in a cecostomy or ileostomy, because following such procedures the water loss is considerable. Until water balance has been reestablished, the patient should not be operated upon. Because many of these patients have lost weight and are likely to have a low glycogen content of the liver, it is the rule on our service to give a high caloric, non-residue diet with large amounts of sugar. We use preferably pure sugar stick candy and large amounts of sweetened fruit juices. In this way the glycogen content of the liver is restored and considerable food value is given.

In addition to decompression of the bowel and hydration of the patient, other preoperative measures of great importance are the replacement of deficient vitamins and the reestablishment of normal content of plasma proteins. As the result of the infection associated with the ulcerative process in malignant lesions, we have found that a marked vitamin c deficiency invariably occurs. The administration of cevitic acid in doses of 200 mg. a day is imperative because vitamin c deficiency, as been shown by Saitta,<sup>85</sup> Zoltan,<sup>86</sup> Lanman and Ingalls,<sup>87</sup> Taffel and Harvey,<sup>88</sup> and Allen,<sup>42</sup> interferes with wound healing. It is our observation, too, that vitamin c deficiency greatly predisposes to infection, thus setting up a vicious circle, the deficiency *resulting* from the infection, and the deficiency in turn *predisposing* to the infection. In cases in which there has been a long continued obstruction, the adminis-

tration of vitamin B preoperatively is of importance. It has been shown clinically and experimentally that vitamin B exerts a definite tonic effect on the large bowel. Sparks and Collins<sup>89</sup> showed that the volume of the colon of rats, maintained on a vitamin B deficient diet, was greatly increased. Vitamin B deficiency has been found by Saitta<sup>90</sup> to interfere with wound healing.

Many patients with carcinoma of the colon, particularly those with lesions on the right side, have a profound anemia, as originally emphasized by W. J. Mayo,<sup>91</sup> in 1913. Alvarez et al.<sup>62</sup> showed that carcinoma of the cecum and ascending colon has a marked tendency to produce severe anemia and they believe that the anemia is dependent upon the surface area of the tumor. They also believe that the size of the colon has a great deal to do with the anemia in that the diameter of the cecum is approximately 6 cm. as contrasted with that of the sigmoid which is 2.5 cm. A much smaller lesion in the sigmoid will produce an obstruction and will cause the patient to seek relief earlier and before the anemia becomes severe than a similar lesion in the cecum. These investigators<sup>62</sup> are of the opinion that the anemia is due to the oozing of the blood from the large ulcerating area which is also a site through which bacteria can enter. Abel<sup>9</sup> found that the average red blood cell count in lesions of the cecum and ascending colon was slightly under four million as contrasted with over four million in the other types. The lowest hemoglobin determination in right-sided lesions was 32 per cent, the highest 90 per cent, and the average 72 per cent. The average hemoglobin determinations for lesions of the transverse colon and splenic flexure were 76.3 per cent and 77.2 per cent respectively. Coons<sup>92</sup> found that the average hemoglobin reading in cases of carcinoma of the cecum and colon was 61 per cent. However, many of these had readings lower than 30 per cent. He also found that the degree of anemia was directly proportionate to the size of the



tumor. Karsner and Clark<sup>55</sup> found that the maximum, minimum, and average hemoglobin percentages for the right half of the colon were 101 per cent, 24 per cent, and 72 per cent, respectively, whereas the respective figures for the left half were 85 per cent, 60 per cent, and 74 per cent. Corresponding erythrocyte counts were 4,850,000; 2,560,000 and 4,035,000 for the right half and 5,464,000; 3,010,000 and 4,408,000 for the left half. Rosser<sup>45</sup> found that anemia occurred almost as constantly in tumors of the transverse colon and the flexures as in tumors of the right colon. He found that a severe anemia occurred in 38 per cent of tumors of the right colon, 30 per cent of the midcolon, and only 6 per cent of the left side. Obviously, the preoperative preparation of patients by repeated transfusion in order to combat the anemia and to replace the plasma proteins is of importance. This is particularly so in view of the recent investigations of Thompson, Ravdin, and Frank,<sup>93,94</sup> who showed that in the presence of a hypoproteinemia there is definite interference with the wound healing. At the anastomotic site following operative excision and reuniting the bowel, edema and retardation of healing are likely to occur as the result of hypoproteinemia. This can be obviated by the replacement of the normal protein which is easily accomplished by the administration of plasma or whole blood.

There has been considerable controversy, particularly recently, concerning the value of peritoneal vaccination. The use of preoperative vaccination of the peritoneal cavity by the introduction of killed streptococci and colon bacilli was popularized by Rankin,<sup>82,84</sup> Bargen,<sup>95,96</sup> and Dixon.<sup>76</sup> Dixon<sup>97,98,99</sup> still advocates this method of preoperative therapy and believes that the preoperative vaccination greatly reduces the mortality rate. In a recent discussion, he<sup>100</sup> stated that in a series of 180 resections of the colon in which intraperitoneal vaccination had been previously performed, there was a total mortality of 6 per cent as contrasted with a similar series in which no

vaccination was done with a mortality of 17 per cent. In another publication, Dixon<sup>98</sup> declared that the vaccination decreased incidence of peritonitis at the Mayo Clinic following resection of the colon from 10 per cent to 1 per cent. He stressed the importance of increasing the peritoneal exudate, and stated that a normal peritoneal fluid, which consists largely of monocytes and has a count of about 2,000 per cu. mm., seventy-two hours after the vaccination becomes increased to 95,000 with a very marked increase of polymorphonuclear leucocytes. He<sup>99</sup> also states that more than 2,500 intraperitoneal injects of the vaccine have been given at the Mayo Clinic.

Rankin, who was an ardent advocate of the use of vaccine, as evidenced by reports in 1932<sup>82</sup> and 1934,<sup>84</sup> more recently<sup>101</sup> has discontinued the use of vaccine and believes that the decrease in the mortality rate as previously reported was not due to the use of vaccine but was due to the rehabilitation of the patient and appropriate decompression of the bowel prior to operation. He reports 130 cases with only eleven deaths (8.4 per cent) without the use of vaccine.

Steinberg<sup>102,103</sup> has shown that it is possible to increase the cellular content of the peritoneal fluid by the introduction of his vaccine at the time of operation. This results in an intense reaction of the peritoneum occurring much more rapidly than the growth of organisms. These observations have been corroborated both experimentally and clinically by Collier and his associates.<sup>104,105</sup> These authors are of the opinion that equally good results can be obtained from the use of Steinberg vaccine without the necessity of increasing the peritoneal reaction prior to operation and that the use of the vaccine can be reserved only for those cases in which actual spillage has occurred. Our experience is similar to that of Collier and we feel that the preoperative vaccination is not only unnecessary but undesirable because should accidental spillage occur at the time of operation gross infection of the peritoneum

can be largely obviated by the use of the Steinberg coli bactragen. Obviously, no vaccine will ever take the place of clean surgery, a point which cannot be overemphasized.

There is considerable controversy concerning the best anesthetic to be used in operating upon patients with malignant lesions of the bowel. There is, however, an increasing tendency towards the use of spinal analgesia particularly since the introduction of those anesthetic agents which have a prolonged action. One of the disadvantages of novocaine is that the analgesia is too short to complete an extensive operation. Finsterer,<sup>20</sup> Haggard,<sup>37</sup> Marvin and Donaghy,<sup>106</sup> Behrend,<sup>107</sup> and Cattell<sup>75</sup> all prefer spinal analgesia.

There are definite advantages of spinal analgesia in resecting malignant lesions of the bowel although it must be admitted that in general, spinal analgesia probably is not quite so safe from the anesthetic standpoint as inhalation anesthesia. It is a rule on our service, to use spinal analgesia given by a trained anesthetist in all extensive intra-abdominal procedures. We feel that the advantages to be derived from the use of the spinal analgesia outweigh the disadvantages and the slightly increased danger from the introduction of the analgesic agent into the spinal canal. Complete relaxation, absence of straining, absence of vomiting, and the ease with which the operative procedure can be performed, justify the use of this method. Ravdin and his associates<sup>108</sup> on the basis of their investigations are of the opinion that of all the anesthetics, spinal analgesia produces the least liver damage. It should be emphasized, however, that spinal analgesia should not be chosen as a method of analgesia in order to dispense with an anesthetist. We feel that if ever the services of a trained anesthetist are necessary it is in the use of spinal analgesia employing the newer anesthetic agents, such as nupercaine and procaine.

Rankin<sup>101</sup> has abandoned spinal analgesia because of the inability to control it. Allen<sup>42</sup>

prefers a properly administered gas anesthesia but states that the anesthetic of choice depends more upon the individual administering it than the agent itself.

Whereas everyone is in agreement that in the presence of obstruction the one-stage procedure is probably never justified, particularly on the left side, there is still considerable dispute concerning the type of operation to be used in the absence of obstruction. With few exceptions, the two-stage procedure is used for left-sided lesions in the presence or absence of obstruction because of the danger of insufficiency of the suture line unless a decompressive operation is preliminarily or simultaneously performed. Until relatively recently it was the consensus that right-sided lesions could be resected with impunity in one stage. However, due to the investigations of Allen<sup>42</sup> and Rankin<sup>109</sup> the desirability of using two-stage procedures in right-sided lesions is becoming more evident. Of twenty-one one-stage procedures done for right sided lesions by Abell,<sup>9</sup> seven died (32.9 per cent) whereas only one of six two-stage procedures (16.6 per cent) succumbed. Von Haberer<sup>83</sup> states that of 172 patients with one-stage resection without colostomy, forty-five (25 per cent) died, whereas of 109 with resection and colostomy twenty-two (20 per cent) died, but only nine (8 per cent) died as the result of the operation. Cheever<sup>36</sup> had thirty-five cases with preliminary colostomy of which three (8.5 per cent) died and fifty cases without a preliminary colostomy of which twelve (24 per cent) died. Oughterson and Shelton<sup>11</sup> had seventeen cases in which a one-stage operation was done with two deaths (11.7 per cent); fourteen cases in which a two-stage operation was done with two deaths (14.3 per cent); three cases in which exteriorization was done with one death (33⅓ per cent). Paus<sup>12</sup> had a mortality of 29.8 per cent in one-stage operations, 15.7 per cent when more than one-stage was used. Allen<sup>42</sup> had seventy-three cases of right sided lesions with one-stage resection with fifteen deaths (20.5 per cent); and

eighteen with two-stage resection with two deaths (11 per cent). Of nineteen one-stage resections of the transverse colon three died (15.7 per cent); and of twelve two-stage resections, two died (16.6 per cent). Of ninety-six one-stage resections of the left colon, nineteen died (20 per cent) and of seventy-three two-stage resections, ten died (13.7 per cent). This represented 6 per cent of the 400 one-stage and  $3\frac{1}{2}$  per cent of the two-stage operations. Allen is of the opinion that the two-stage operation even for right-sided lesions, is the method of choice. Grey Turner<sup>7</sup> reported a mortality rate of 25.7 per cent in seventy one-stage resections of the large bowel as contrasted with a mortality of 12.5 per cent in seventy-two multiple stage resections.

An exteriorization procedure (Bloch,<sup>110</sup> Paul,<sup>111</sup> Mikulicz<sup>112</sup>) may be used in some cases. Because of the high incidence of metastases to the abdominal wall, which according to him is 7 per cent following the original exteriorization procedures, Rankin<sup>113</sup> has advocated obstructive resection particularly in sigmoid lesions. This consists of division of the mesentery similarly as for resection but instead of performing a resection with anastomosis, clamps are placed on the proximal and distal loops and the bowel removed distal to the clamps. The proximal clamp is kept in place for a period of twenty-four to seventy-two hours and then removed. The distal clamp is kept on until it sloughs off. MacFee<sup>23</sup> reports a mortality rate of 27.9 per cent in sixty-eight cases in which the exteriorization procedure was used, 16.1 per cent in fifty-six cases in which aseptic primary anastomosis was done, and 18.8 per cent in thirty-two cases in which open anastomosis was done. The use of the aseptic anastomosis and its value in decreasing the mortality rate has been emphasized by Rankin<sup>109</sup> and Allen.<sup>42</sup> Kauffmann<sup>114</sup> warns against the use of exteriorization operation in acute obstruction. Of ten cases so treated, seven died. Rankin,<sup>109</sup> for right-sided lesions, advocates ileotransverse colostomy performed asep-

tically and followed either at the time or subsequently by resection of the bowel. In left-sided lesions, he prefers preliminary drainage of the right side followed by resection or by obstructive resection. In sixty cases of right-sided lesions in which an aseptic ileotransverse colostomy was done, there were only four deaths (6.6 per cent). In cases of left-sided lesions in which obstructive resection was done, the mortality rate was 9.6 per cent. Lahey<sup>78,115</sup> advocates an exteriorization operation with obstructive resection in right-sided lesions. Wilkie<sup>15</sup> had thirty-eight cases in which primary resection was done with five deaths (13 per cent), thirty cases with resection and preliminary colostomy, with three deaths (10 per cent) and twenty-six cases with exteriorization, with five deaths (19 per cent). He emphasized that those cases in which the exteriorization procedure was done were borderline cases as regards operability. Gordon-Watson<sup>40</sup> states that multiple stage operations reduce the mortality rate about one half. Cattell<sup>79</sup> stated that during the period in which primary resection was done without preliminary colostomy, one out of every seven died of peritonitis. Since the introduction of the multiple stage operations, the mortality rate has been cut in half. Two-stage procedures are preferred by Lahey,<sup>116</sup> Dixon,<sup>117</sup> Ransom,<sup>118</sup> and McKittrick.<sup>119</sup>

In carcinoma of the colon, peritonitis is the most frequent cause of death both in operative and non-operative cases. In the latter instance, the ileus with permeation of the bowel by bacteria or the penetration of the bowel by the tumor are responsible for the peritonitis. In the former instance, contamination at the time of the operative procedure or as the result of permeation of the bowel by micro-organisms is responsible for the peritoneal infection. In a collected series of 412 fatalities<sup>2-4,6,7,19,24,39,42,120</sup> following resections for carcinoma of the bowel, 172 (41.7 per cent) were due to peritonitis. Mayo and Simpson<sup>24</sup> reported that of nineteen deaths following extra-peritoneal resection of the transverse colon,

twelve were due to peritonitis, and of four deaths following a resection with primary anastomosis, three were due to peritonitis and one other due to separation of the sutures. Of seven deaths following a resection of the right and transverse colon for carcinoma, two were due to peritonitis and two additional ones to separation of the sutures. Of nine deaths following palliative procedures for carcinoma of the transverse colon, six were due to peritonitis. Thus of thirty-three deaths following operation in 204 cases of carcinoma of the transverse colon, eighteen were due to peritonitis and three more due to separation of the suture line, making a total of twenty-one of the thirty-three due to peritonitis. In Allen's<sup>42</sup> series, peritonitis accounted for thirty-three of 110 deaths (30 per cent) following resection of the large bowel. There were twenty-four deaths from peritonitis in 400 one-stage operations, and nine deaths from peritonitis in 253 two-stage operations. Rankin<sup>6</sup> found that peritonitis was the cause of death in fourteen of twenty-six fatalities in 385 palliative colostomies and also in ten of sixteen deaths in 584 cases in which a preliminary colostomy was performed and in which the growth was deemed resectable.

It is thus seen that peritonitis is the most important complication in cases of carcinoma of the colon. As mentioned above, a great deal can be accomplished by appropriate management, i.e., careful preparation of the patient; relief of obstruction; use of aseptic anastomosis; and in those cases in which accidental spillage does occur, the use of the Steinberg coli-bactragen.

Pulmonary complications are second to peritonitis as a cause of death in carcinoma of the colon. Shambaugh<sup>120</sup> found that of fifty-two cases coming to autopsy following surgery of the large bowel, of which forty-eight were for carcinoma, nineteen had pneumonia and an additional one pulmonary embolism. Of 110 deaths reported by Allen,<sup>42</sup> twenty-eight were caused by pulmonary complications; twenty-two of these followed 400 one-stage operations and

six followed 253 two-stage operations. As Allen has emphasized, it is of significance that the incidence of pulmonary complications was distinctly lower following the two-stage operations than following the one-stage operation, in spite of the fact that two operations gave a double opportunity for the development of pulmonary complications. This, he believes, is due to the fact that the patients were in better condition and were better able to withstand the pulmonary infection. Rankin<sup>6</sup> observed seven cases of pulmonary complications in twenty-six deaths occurring in 385 cases in which a palliative operation was done for carcinoma of the colon. Five of these were bronchopneumonia, one pulmonary embolism, and one pulmonary edema. Of sixteen deaths occurring in 584 cases in which colostomy was done preliminary to a resection, six had pulmonary deaths, two pulmonary embolism, one pneumonia, and one empyema. Larson<sup>28</sup> had seven pulmonary deaths in 210 cases of carcinoma of the colon coming to autopsy, an incidence of 3.3 per cent.

Peritonitis is the most frequent complication as well as the most frequent cause of death. Second in frequency are pulmonary complications.

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STERILITY of the operative field is impossible to obtain in surgery of the rectum and anus except in a few operations which are performed through a perianal skin incision without entering the bowel lumen.

# DIAGNOSTIC VALUE OF SIGMOIDOSCOPY AND BIOPSY

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THE preëminent value of sigmoidoscopy is for: (1) the discovery of small tumors at their onset; (2) differentiation of other diseases having similar symptoms; (3) exclusion of the terminal bowel (distal pelvic colon, rectosigmoid and rectum) as the site of a neoplasm; and (4) to obtain material for smears and culture, and tissue for histologic study.

*Indications.* Symptoms referable to the colon and the rectum indicate instrumental examination. These include a change in bowel habit, especially progressive constipation; abdominal unrest and distention; intestinal cramps; bearing down or fullness in the pelvis; morning urgency with the mere passage of flatus and some blood-tinged mucus; frequent sanious discharges of blood, pus and mucus, anemia and weight loss.

By digital palpation, which should always precede sigmoidoscopy, the experienced clinician can usually diagnose correctly a carcinoma situated within 5 inches of the anal verge.

It is an all too common practice when the symptoms suggest a lesion of the large bowel, to refer the patient at once for an x-ray study. The procedure should be reversed and the data obtained by proctosigmoidoscopy should be given to the roentgenologist *before* his examination. Ulcers and small tumors within the bony pelvic girdle cannot, as a rule, be visualized by the x-ray, whereas direct inspection through the tube reveals at once their presence and character. Sigmoidoscopy is our chief reliance for the discovery of an incipient tumor. A negative Roentgen report frequently engenders a sense of false security until the neoplasm has progressed to a hopeless stage.

The vast majority of inflammatory and neoplastic lesions of the large bowel involve its terminal 12 inches. Consequently they are within range of digital palpation or endoscopy. This is notably true of neoplasms.

During the years 1931-1938 inclusive, 5,723 patients were discharged from the New York City Cancer Institute with the proved diagnosis of malignant disease. Segmental incidence of carcinoma in the digestive tract was: esophagus 163; stomach 560; small intestine 2; cecum 21; colon 49; sigmoid and rectosigmoid 85; rectum 422; this constituted a total of 1302 or 22.7 per cent of all cases discharged. Of the 577 large bowel involvements, 422 (73 per cent) were in the rectum.

Sigmoidoscopy is a relatively simple office procedure. No anesthesia is used, but adults with tender anal lesions may require local anesthesia, and unmanageable infants and children general anesthesia.

An empty bowel is essential, best obtained by 1 ounce of castor oil taken the night before the examination, or by enemas of warm water three or four hours in advance. These measures are omitted if the patient has diarrhea.

With the passage of time ever increasing numbers of physicians appreciate the great value of sigmoidoscopy in diagnosis. Any one interested can become proficient in introducing the tubes, but considerable experience is required to interpret correctly the findings.

*Technique.* The patient is placed in the knee-shoulder position or is inverted on a Hanes' or similar table.

The technique of sigmoidoscopy is given in detail in books on proctology. Suffice it to say that after the tube has entered the



rectal ampulla, the obturator is removed to gain the benefit of atmospheric pressure to distend the bowel. Its further passage must

Factors arresting the tube at the recto-sigmoid are spasm of the bowel musculature, a short mesosigmoid, adhesions fixing

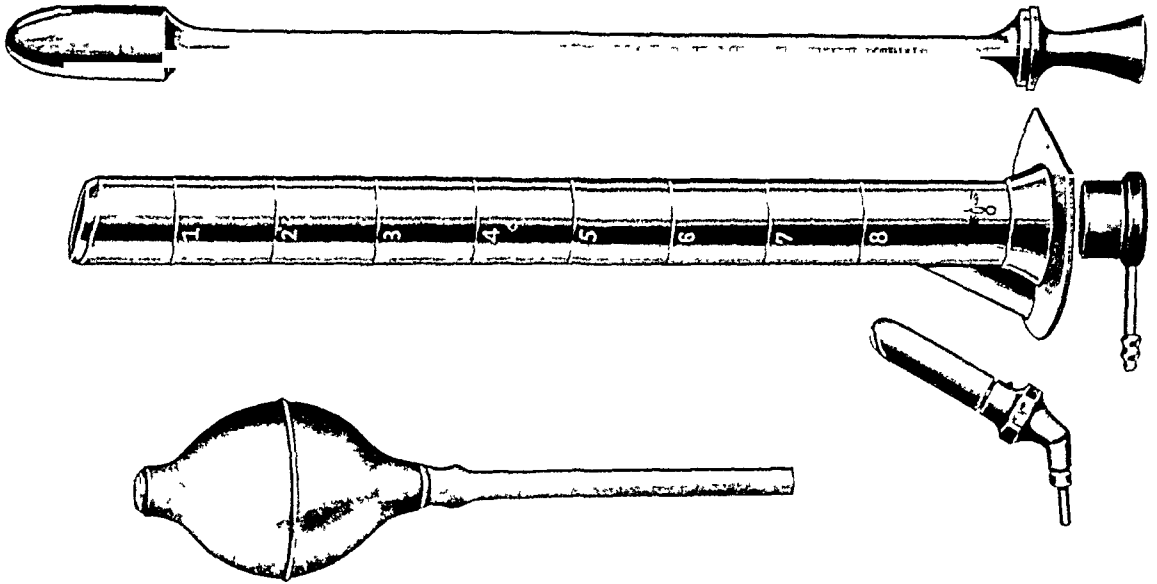
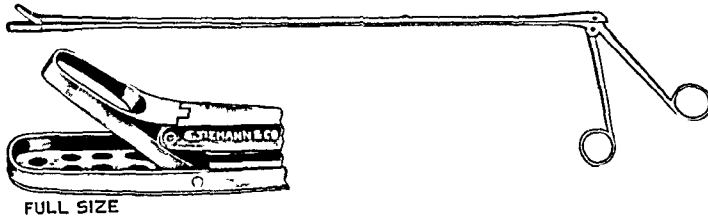


FIG. 1. Yeomans' pneumo-electric proctoscope.

be guided by direct vision lest serious injury or perforation of the bowel occur. Perforation is a most serious, frequently fatal, accident that should never occur with proper technique. Pathologic lesions, such as ulcer or cancer, render the bowel wall friable, and the thinned wall of the sigmoid in emaciated persons is easily perforated.

the sigmoid in an abnormal position, organic stricture and neoplasms. However, inspection of an obstructive organic lesion is usually sufficient to establish the diagnosis. Extra-intestinal conditions arresting the tube are the uterus fixed in retroversion, diseased adnexa and adhesions, and fibrous bands following operations on the pelvic organs.



FULL SIZE

FIG. 2. Yeomans' biopsy forceps.

For a satisfactory examination the tube should be passed at least 10 inches (25 cm.). Fortunately this can be accomplished in about 85 per cent of individuals having a normal bowel or only superficial pathologic changes of the mucosa. The limit of advancement is the apex of the sigmoid which varies from 10 to 14 inches from the anus. Close inspection while the tube is being withdrawn frequently yields the most valuable information.

When a carcinoma involves the entire circumference of the bowel wall, the calibrated tube of  $\frac{1}{2}$  inch diameter can usually be passed through its lumen to the normal mucosa above the growth, thus determining at once the length of the lesion.

Data obtainable by proctosigmoidoscopy are: (1) the appearance of the mucosa—normal, atrophic or hypertrophic; (2) recognition of various types of

ulceration, such as tuberculous, amebic, hemorrhagic and chronic nonspecific; (3) the identification of inflammatory stricture; (4) determination of the number, site and distribution of small non-malignant growths, or of carcinoma in all its stages of development; (5) taking material directly for smears and cultures.

*Biopsy.* To one experienced in the interpretation of a digital palpation, a carcinoma within the palpable area imparts a feel that is diagnostic. However, in all cases of doubtful diagnosis, such as indurated ulcer, amebic or tuberculous granuloma, stricture or tumor, a biopsy is taken with the harmless high-voltage electric snare or punch forceps passed through the proctoscope. This is especially necessary when these lesions are situated beyond reach of the finger and the valuable data of palpation are not obtainable.

The alleged danger of disseminating cancer cells by a properly performed biopsy is minimal in comparison to the positive information obtained. If the tumor is very small, the entire lesion is removed for study. Under direct vision a specimen is taken at a point in the pathologic process most likely to yield the maximum information by histologic study. If the lesion is ulcerated, the specimen is taken from its margin, avoiding necrotic tissue. In non-ulcerated neoplasms the specimen is taken from the tumor itself.

No bleeding follows electric snare biopsy. Immediately after biopsy with the punch forceps, 95 per cent phenol is applied to the wound, and is followed by alcohol; the excess is sponged away. This topical application quickly controls any slight bleeding and effectively seals the lymphatics.

When indicated, biopsy is a part of the routine examination and the patient is not aware that a specimen has been taken. Exceptions to this are: a melanoma, which should never be cut into; a submucous tumefaction, the result of a chronic perirectal inflammation; and a malignant infiltration of colloid carcinoma or sarcoma where the mucosa is intact. If biopsy is

decided upon in the latter cases, it should be done carefully by incision with the endotherm knife which seals the lymphatics and small blood vessels, and generally under spinal or general anesthesia.

Biopsy is, as a rule, contraindicated in certain pathologic conditions in which the intact mucosa is usually movable over the surface of the tumefaction but is not grossly implicated in the pathologic process. Examples of this are enlarged lymph nodes of the mesorectum, notably in children with tuberculous adenitis; metastatic involvement of these nodes by carcinoma in adults, and infiltration of the rectovesical pouch or cul-de-sac of Douglas by metastases from malignant tumors or plastic tuberculous peritonitis. In these cases local and general findings, together with other clinical data, usually suffice for a correct diagnosis.

Histologic study of a representative biopsy (1) clinches the diagnosis in doubtful cases; (2) may determine the grade of malignancy of a tumor; and (3) may influence the type of therapy. The highly malignant cancers, graded 3 and 4, are, theoretically at least, more sensitive to irradiation than are those graded 1 and 2.

There are two conditions in which sigmoidoscopy suggests the diagnosis but is not conclusive. In neither of them can the tube be passed beyond the rectosigmoid and bleeding is the leading symptom. One of these is an adenoma in the upper rectum. Its removal may be followed by temporary relief of the bleeding, but within a short time a carcinoma of the pelvic colon is manifest. The adenoma was the "outpost" or danger signal of the more important condition.

The other condition is a carcinoma associated with diverticulitis of the sigmoid. This association is relatively common after the fortieth year and has been found at operation in from 4 to 30 per cent of cases. These citations emphasize the necessity of a Roentgen ray study of the colon with an opaque enema in all cases in which the tube is arrested at the rectosigmoid juncture.

# INJURIES OF THE COLON

## REVIEW OF SIXTY-TWO CASES IN NEGRO PATIENTS

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### INCIDENCE OF SURGICAL DISEASES OF THE COLON IN NEGROES

IT has been shown many times that surgical diseases of the alimentary tract are far less common in negroes than in white people. Racial characteristics may play a part in this difference, but diet is an important factor. Individuals like the East Indians who subsist on so-called "natural" foods escape almost entirely such lesions as peptic ulcer, gall-bladder disease, appendicitis and carcinoma of the digestive system. Such foods are those which are grown in the community where they are consumed with little delay, and are subjected to but little packing, shipping and storing. On the other hand these diseases occur with marked and increasing frequency in a population whose foods are polished, pickled, frozen, thawed, sterilized and canned, and then transported to distant places where they may remain a long time before being used.

The negro of our Southern states lives on food somewhat similar to that of the East Indians, and a survey of ten years ago made in Atlanta demonstrated that these diseases were four times as common in the white as in the colored race. More recently, as the city-dwelling negro takes on the habits and nourishment of his white neighbor, he has become more subject to the afflictions of the Caucasian. Now these surgical diseases of the alimentary tract are believed to be only twice as common in white patients as in colored.

Such is the record of carcinoma of the colon. During the eight-year period, 1931-1938, among approximately the same number of admissions to the Grady (municipal) Hospital, of Atlanta, there

were thirty cases of the disease in white patients, and fifteen in negroes. Traumatic cases, however, show a much higher incidence in the colored race.

### INJURIES OF THE COLON

The majority of injuries of the colon are penetrating wounds made by bullets or sharp instruments. Injuries without penetration of the abdominal wall are rare, and there was none in the present series. In 279 cases of gunshot and stab wounds of the abdomen in the Grady Hospital during the past six years (1933-1938) sixty-one (22 per cent) involved the colon, forty-two being due to bullets and nineteen being classed as stab wounds. The latter were made by various kinds of long-bladed knives, intended for the purpose, and turned out to be incisional rather than stab wounds. Contrary to tradition, the razor was used in only one instance, but the result was a penetrating wound extending half way around the body. In one case air was injected into the colon through the rectum, the details being as follows:

The patient was a male aged 20. With a unique idea of being playful, a companion passed an alemite gun under the patient's coat between his buttocks, and let go a volume of air under 180 pounds pressure. The nozzle of the gun was not inserted through the anus, and it is said that this is not necessary in order for air or gas under pressure to enter the rectum. The patient was blown a distance of 8 or 10 feet, and he declared that he felt full of air from "his heart to his rectum." As he attempted to rise he passed a large amount of air from the rectum and then became unconscious. Brought immediately to the hospital he was cold and clammy, and when he regained consciousness he cried out with great abdom-

inal pain. Maximum tenderness was present in the lower abdomen, especially over the cecum. There was rigidity at first which soon disappeared. There was no distention.

Rectal examination revealed slight tenderness, no masses or discharge, no blood on the examining finger. Palpation over the ascending colon gave a sensation of crepitus. Leucocytes, four hours after the accident, were 17,000. The red blood count was remarkable, and inexplicable. In a patient previously in good health, the red cells four hours after injury numbered 6,995,000, when counted by several competent observers. Hemoglobin was 75 per cent. Wasserman was negative. The high red blood count remained about the same for four or five days, then reached normal. Fluoroscopic examination showed no free air in the peritoneal cavity.

Laparotomy under spinal anesthesia was done through a left paramedial incision. There was no escape of gas when the peritoneum was opened. A small amount of bloody fluid was present. No perforation of the colon was discovered, but the lateral tenia coli of the cecum was split longitudinally through the peritoneal coat for 4 inches, while the same amount of injury existed in the tenia coli on the anterior surface of the sigmoid. Three shorter tears of this kind were found, all longitudinal. The wounds were sutured with fine chromic catgut and the abdomen closed without drainage. The patient was dismissed after two weeks in good condition.

The majority of the patients reached the hospital within from one-half hour to four hours after injury. Negroes with mysterious internal disorders are loath to go to a hospital, but when they are shot or stabbed they know they need prompt attention, and enter the hospital immediately.

All bullets entered the body from the front, and not a single wound of exit was reported. The bullets were lost in the tissues of the body except in a few reported cases in which symptoms revealed the resting place.

In spite of the opportunity for early treatment the mortality in the group seems high. The number of deaths in sixty-two patients was twenty-nine, a mortality of 47 per cent. In three patients who died

the colon was the only viscus injured. Twenty-three patients succumbed to gunshot wounds (60 per cent) and six to stab wounds (31 per cent). There were twelve deaths in the first twenty-four hours (three patients dying on the operating table), and eight additional deaths in the first forty-eight hours, demonstrating that hemorrhage and shock were the main causes of mortality. Three patients developed peritonitis and died, a small incidence of this complication in view of the foul contents usually found in the peritoneum. There were three cases of pneumonia with one recovery.

The segments of the colon injured were as follows:

Cecum.....	4
Ascending colon.....	3
Transverse colon.....	30
Hepatic flexure.....	4
Descending colon.....	7
Sigmoid.....	5
Mesocolon only.....	3
Ascending and transverse colon.....	1
Transverse and descending colon.....	1
Mesoappendix.....	1
Abrasions of transverse colon.....	1
Abrasions of cecum and sigmoid.....	1
Evisceration only.....	2

The small intestine also was involved in twenty-nine cases, and the stomach in six cases. There were ten cases of liver injury, but none required suture. The kidney was injured in three patients, resulting in nephrectomy and death; splenectomy was performed in three patients, with one recovery. It was necessary to repair the tail of the pancreas in one patient who survived. In one-third of the patients the colon was the only abdominal viscus injured.

Combined tetanus and gas bacillus antitoxin was given routinely. All the patients were operated upon promptly; ether was administered in all cases except seven, when spinal anesthesia was employed. In several instances ample abdominal incision was already made by the patient's assailant; otherwise the abdomen was opened through a median or paramedial incision. Blood and blood clots were present in

amounts varying from a few drops to as much as 1,500 or 2,000 c.c. The first indication was to find and control bleeding points. Blood, food and feces were removed by suction or gentle wiping with saline sponges. In closing openings in the mesocolon care was excised to avoid interference with the blood supply of the gut. All perforations of the colon were closed without resection and anastomosis. Three patients had excision of segments of the small intestine. In one case 8 inches were removed, with a fatal outcome; in another case three inches were taken out, with recovery; and in another 2 feet of small intestine were excised, with recovery. Fine black silk and fine chromic catgut on atraumatic needles were used in intestinal suture. Peritoneal drainage was instituted in twenty-seven cases.

Blood transfusion was used six times, and no doubt more transfusions would lower the number of fatalities. Finding donors for this class of patients is difficult, and typing and matching takes time. It seems an ideal set-up for using the blood bank, but such a method has not met with favor in this institution on account of violent reactions.

#### CASE REPORTS

Eight cases are selected for detailed description:

**CASE I.** Male, aged 25. The patient was brought into the hospital propped on an elbow with a large part of his stomach, 20 feet of small intestine and part of the transverse colon hanging out of an abdominal wound, said to have been made with a razor. Examination showed the incision extending from the tenth dorsal spinous process almost to the umbilicus. The patient did not seem to be in great pain or shock. His temperature was 101, pulse 66, respiration 24. Hemorrhage was moderate and a small amount of feces was seen oozing through an opening in the splenic flexure. The only other injury was a slight laceration of the capsule of the left kidney.

The patient was given 1,000 c.c. of distilled water with 5 per cent dextrose intravenously, and under ether anesthesia the exposed viscera

were wiped clean with saline sponges, lacerations repaired with fine chromic catgut, viscera replaced, one Penrose drain inserted, and the abdomen closed with No. 1 chromic catgut and silk.

The patient recovered slowly, and five days later received 420 c.c. whole blood by the Rudder method. He was dismissed in good condition after three weeks.

**CASE II.** Male, aged 22. The patient came immediately to the hospital after being shot in the left upper abdomen. The wound was 21 cm. long. The patient's general condition appeared to be good, and temperature, pulse and respiration were normal.

Under spinal anesthesia the incision was enlarged. The abdomen contained a large amount of free blood which arose from two superficial, non-penetrating wounds on the anterior surface of the transverse colon and two perforations on the posterior surface of the splenic flexure. The peritoneum was cleaned, perforations sutured, and the abdominal wound closed without drainage. Two days later the patient was operated upon, under spinal anesthesia again, for intestinal obstruction which was found to be in the terminal ileum. The obstruction was released, but the patient continued to grow worse, and died on the fifth day. Autopsy revealed an abdomen filled with pus, some bloody and some yellow, 800 c.c. being removed from the right subphrenic space, 500 c.c. from the left flank, 800 c.c. from the pelvis, and more pus from many pockets. No further intestinal perforations were discovered.

The final diagnosis was general peritonitis, bronchopneumonia, lobar pneumonia of the right middle lobe, and bilateral hypostatic pneumonia.

**CASE III.** Male, aged 31. This patient entered the hospital with a recent bullet wound in the right upper abdomen. His condition was fair, and pulse, temperature and respiration were normal. There was slight abdominal rigidity, and he complained of pain in the region of the rectum.

Immediate operation was undertaken under ether. The bullet had cut the liver, the colon just below it, and then had lacerated the lower pole of the right kidney. The kidney, bleeding profusely, was delivered through the mesocolon, and was removed. The patient was unable to void and a retention catheter was inserted. At first he complained of severe pain

in his left leg and then all feeling disappeared. A roentgenogram showed fragments of lead in the back and a comminuted fracture of the third lumbar vertebrae. Before complete neurologic diagnosis was made the patient's abdominal wound broke open and it was necessary to resuture under ether anesthesia. He died the same day.

CASE IV. Male, aged 28. This patient had received a stab wound in the right upper abdomen, and entered the hospital with a long loop of small intestine hanging out. On admission his pulse was 115, temperature 102 and respiration 28. Two thousand c.c. of normal saline were given intravenously at once, and 2,000 c.c. of distilled water with 5 per cent dextrose were administered the same way after operation and repeated often.

Under spinal anesthesia the wound was enlarged, and the abdomen found to contain a small amount of blood and considerable pork and collards. A small perforation in the anterior stomach wall was sutured with silk and a hole in the mesocolon closed with chromic catgut.

Recovery was slow. One month later a blood transfusion was given, followed by an operation under ether to close a suspected gastric fistula which proved to be three fistulae of the jejunum. These were repaired, and the patient recovered after six weeks.

CASE V. Male, aged 39. The patient was admitted to the hospital one hour after he was shot in the left side of the abdomen. His condition was good, pulse 104, respiration 24, temperature 99. There was but little abdominal rigidity. Laparotomy through lower right rectus incision showed two holes in the hepatic flexure of the colon, which were closed with silk. A small opening in the liver did not bleed, and was not disturbed. Severe hemorrhage was coming from the left side of the abdomen so that a second incision was made which revealed a wound in the tail of the pancreas and a badly lacerated spleen. The injured pancreas was sutured and the spleen removed. A roentgenogram made two days after admission showed a comminuted fracture of the right ilium. The patient was dismissed, well, after thirty days.

CASE VI. Male, aged 38. The patient entered the hospital two hours after receiving a gunshot wound of the abdomen. There was a small opening 2 cm. to the right of the umbilicus. His condition was good, pulse 80,

respiration 24, temperature 24. He was taken immediately to the operating room, and under ether, a right rectus incision was made. A small amount of free blood was found in the peritoneal cavity. Exploration demonstrated a perforating wound of the terminal ileum, two openings in the transverse colon and a slight laceration of the liver which was not bleeding. The injured intestine was repaired and the abdominal wound closed without drainage.

Fluids were administered intravenously and convalescence was satisfactory until the fifth day when the temperature rose to 104. A tender, fluctuating mass was discovered just above the crest of the right ilium, and pus was aspirated. Incision exposed 300 c.c. of thick, foul pus behind the ascending colon, communicating with a perforation which was overlooked during the first operation. The abscess cavity extended back to the sacroiliac joint where the bullet had entered the bone without injury to other tissues. There was considerable bleeding, and it was necessary to make a second incision posterior to the first one in order to obtain good exposure. The wound was packed with iodoform gauze and closed loosely. The patient recovered after thirty-two days.

CASE VII. Male, aged 27. One hour before admission the patient was shot five times in the chest wall, abdomen and left arm. The penetrating chest wound caused hemopneumothorax, but did not require operative interference. Pulse was 108, temperature 99, and respiration 24; the patient was in moderate shock. At first he felt no pain, then severe abdominal pain and nausea. The bullet involving the abdomen entered the right flank, just above the crest of the ilium.

Five hundred c.c. of gum acacia were given and the abdomen was opened under ether, revealing a moderate amount of free blood. Two perforations were found in the cecum and ten in the middle portion of the jejunum. The wounds in the cecum were sutured with fine chromic catgut, and 3 inches of the jejunum were excised to remove the lacerated portion, end-to-end anastomosis being performed. After operation 500 c.c. of blood from a bank donor were administered; normal saline solution and 5 per cent dextrose in distilled water, in 2,000 c.c. amounts, were repeated at frequent intervals.

Six weeks later intestinal obstruction developed and was confirmed by a roentgenogram

showing many fluid levels. Laparotomy revealed a loop of small gut bound down by adhesions. The outcome was good and two months after the first operation a third incision was made to drain an abscess of the abdominal wall. The patient was dismissed in satisfactory condition after eighty-two days in the hospital.

CASE VIII. Male, aged 23. According to the history, the patient was "cut with knives while attempting a hold-up." He was drunk and in shock. There was evisceration from a large gash in the right side of the abdomen. A sucking wound was present in the right chest and another in the left chest, in addition to several minor lacerations. Pulse was 120, temperature 96, respiration 40, blood pressure 80/60. Under ether-nitrous oxide-oxygen anesthesia, a mass of protruding omentum was removed. Three penetrating abdominal wounds were discovered. From one of the larger ones 4 feet of jejunum and 1 foot of transverse colon eviscerated. Feces escaped from several large wounds

in the colon. There were ten to fifteen scattered lacerations of the jejunum. All the injuries were repaired, the operation consuming one hour. As the abdominal wall was being sutured the patient expired on the operating table. Hemorrhage appeared to be slight. The cause of death was given as shock.

#### SUMMARY AND CONCLUSIONS

1. In gunshot and stab wounds of the abdomen in civil practice the colon is involved in 22 per cent of the cases. The colon alone is injured in 33 per cent of the cases.

2. Hemorrhage and shock are the commonest causes of death. Immediate blood transfusion is indicated in the majority of cases. It is rarely necessary to resect segments of the colon.

3. In a series of sixty-two patients the mortality was 47 per cent. Gunshot wounds are twice as often fatal as stab wounds.



# INDICATIONS AND TECHNIQUE OF COLOSTOMY

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IN 1710, Littré suggested the operation of colostomy with the object of formation of an abdominal anus after he had observed the death of an infant six days after birth due to a congenital deformity of the rectum which prevented defecation. Pillore carried out a successful cecostomy in 1776. It was not until 1783 that Dubois performed the operation of iliac colostomy proposed by Littré, but his patient died. Duret in 1793 performed the first successful left iliac colostomy in an infant with congenital absence of the rectum. Considerable discussion arose as to the merits of a lumbar colostomy which was championed by Amussat and which he successfully carried out in six patients. Baudens in 1842 suggested the oblique lateral abdominal incision, which is now commonly used.

The indications for colostomy are now rather numerous and the operation may be made as a temporary or permanent opening. The most important indication is to relieve obstruction and in this instance the colostomy may be temporary if at a later date the obstruction can be relieved, or permanent if an inoperable obstruction is present. Carcinoma at the rectosigmoid or flexures of the colon accounts for the large majority of these cases.

Temporary colostomy is commonly performed as part of an operative procedure such as the Mikulicz operation or the Rankin obstruction resection of the colon. Colostomy is also temporarily used in diverting the fecal stream from inflammatory or other lesions distal to the colostomy. Among these conditions are intestinal vesical fistulae resulting from diverticulitis, trauma, infections, or on a congenital basis. Temporary colostomy is also occasionally indicated in advanced

rectal stricture, narrowing of the sigmoid from inflamed diverticula, or as a decompressing procedure preliminary to operations on the bowel distal to the colostomy as certain plastic procedures on the rectum.

Permanent colostomy is most commonly performed as a necessary part of removal of the terminal colon and rectum for carcinoma or to relieve obstruction in inoperable growth of the rectum or sigmoid as well as in far advanced strictures of the rectum so commonly seen as in advanced lymphogranuloma inguinale of the rectum.

The types of colostomy vary, depending on its purpose. End colostomy is performed after removal of the rectum or in some instances preliminary to it. The distal end of the bowel is brought out through a left or right gridiron muscle splitting incision for a permanent abdominal anus.

Colostomy in continuity is carried out in the sigmoid loop or transverse colon as a temporary or permanent colostomy without complete division of the bowel wall. Peritoneum, fascia, or skin (Fig. 1) is sewed or a glass rod is placed under the bowel through its mesentery to keep the bowel well up on the abdominal wall and to produce a spur or partition between the afferent and efferent loop to divert the fecal content from the efferent loop out onto the abdominal wall.

Another commonly used type of colostomy is performed in the Mikulicz operation or the Rankin obstruction resection of the transverse colon, splenic flexure, descending colon, sigmoid loop, or rectosigmoid junction. After mobilization of the bowel to be resected and division of its gland bearing mesentery, the affected bowel is exteriorized and the abdominal wall sewed about the afferent and efferent loops of colon. The bowel containing the



growth with its detached mesentery is then removed leaving in the abdominal wall the adjacent afferent and efferent loops of

The technique of performance of these procedures varies considerably, many surgeons having their own favorite methods of

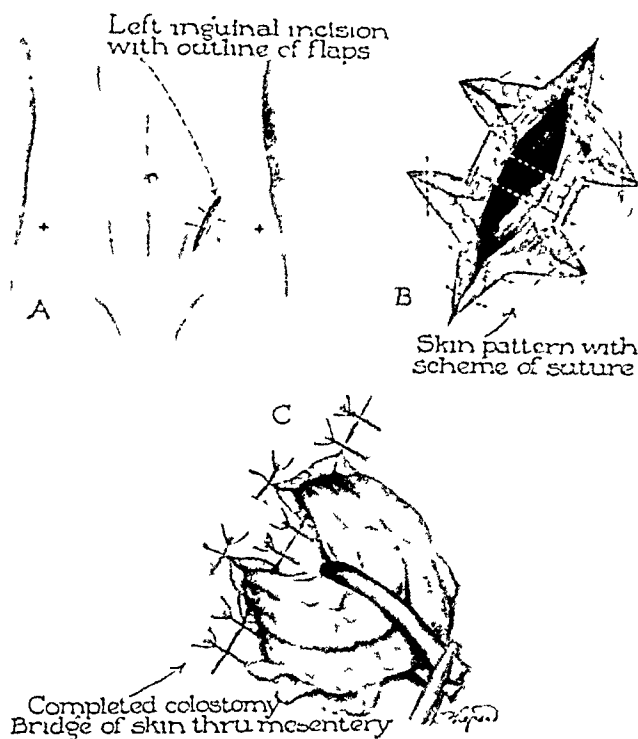


FIG. 1.

healthy bowel. This is a temporary colostomy and is followed by closure of these two loops at a subsequent operation. The object of this type of colostomy is to prevent peritonitis by extraperitoneal division of the colon. It is a most valuable procedure and has materially lowered the mortality of resection of the left half of the colon.

Lastly, a gas vent may be made in the cecum or transverse colon to relieve the symptoms of acute obstruction by drawing out a part of the circumference of the bowel and introducing into it a Pezzer catheter which is held in place by a linen purse-string suture. This procedure does not divert all of the fecal stream but is a gas vent and is useful as a temporary procedure in acute obstruction of the colon or to prevent distention after operations where tension on suture lines distal to it is advisable.

procedure. To avoid an encyclopedic discussion, a few principles of technique will be discussed and some details peculiar to our own fancy will be given.

The most important principle in establishing a successful colostomy is to mobilize freely the bowel which is to be used. In a fat individual with a short mesentery and an obstructed bowel this may be extremely difficult. Mobilization is accomplished by division of the lateral peritoneal attachments of the colon which allows the bowel to be drawn toward the midline and to be lifted up from the posterior part of the peritoneal cavity without interference with its blood supply. This procedure is essential to the successful performance of an obstruction resection operation as well as to colostomy in continuity, for the bowel must lie well above the skin without tension. When this is accomplished, suture of the bowel to any part of the abdominal

wall is unnecessary and indeed dangerous as tension on the sutures cut out and may result in leakage. Wherever possible, colostomy should be done through a lateral muscle splitting incision such as is used in appendectomy, because the bowel is held in place as it comes through the internal oblique muscle, the incision is small and less likely to become infected, postoperative hernia through the incision is less likely, and prolapse of the colostomized bowel is less frequent. The question of greater control of fecal evacuation by reason of muscle encircling the bowel is less certain, as no colostomy that I know of is entirely controllable.

In colostomy in continuity it is imperative that the mesenteric attachment of the bowel be kept well above the level of the skin to produce a spur for diversion of the fecal stream from the distal or efferent loop. As has been said, peritoneum, fascia, or skin can be sewed beneath the bowel through a small opening made in its mesentery. A glass rod cannot be worn permanently with comfort. Our practice is to use skin taken from both sides of the incision and sewed beneath the bowel. (Fig. 1.)

The bowel making the end colostomy must be well mobilized so that 1 to 2 inches of bowel protrudes above the skin without tension. The appendices epiploicae are drawn out with the bowel and tend to hold the bowel in position.

The dressing of the colostomy at the end of the operation is important for it can help in keeping the bowel well up on the abdominal wall and aids materially in prevention of infection of the abdominal incision. Two strips of iodoform gauze 3 inches wide are partially divided longitudinally to make pantaloons. The crotch of the pantalon is laid against the bowel wall and the legs encircle the bowel so that the bowel wall as it emerges from the skin is everywhere in contact with the gauze. Over this iodoform gauze are placed gauze dressings 4 by 6 inches, which are heavily covered with zinc oxide paste. The paste side is down and these are latticed

around the bowel over the iodoform gauze and completely covering the skin. They make a grease watershed, shielding the wound from feces and at the same time make an adherent dressing which sticks not only to the iodoform gauze and surrounding skin but to the bowel wall itself. The dressings which get dirty on the top shield the abdominal incision and should be left in place a week, when they are removed and the skin stitches are taken out. This procedure, which is simple to use, effectively prevents infection of the abdominal wall in most cases.

Lastly, we believe an important principle to observe is early opening of colostomies. When the colostomy is kept closed for two to five days the patient is uncomfortable from gas pressure. Tension on the abdominal wall stitches results if the colostomy is done coincidentally with a bowel resection, which favors evisceration. Of real importance is the danger of raising intra-intestinal pressure with the risk of causing a perforation of a diverticulum of the bowel which is so commonly present in patients of cancer age. That this danger is not theoretical is evidenced by a number of these accidents which we have reported elsewhere.\* Consequently, end colostomies made in conjunction with one stage abdominoperineal resection of the rectum are opened at the termination of the operation and a catheter inserted into the bowel. The next day if gas is not passed spontaneously the bowel is gently irrigated with warm salt solution, 3 to 4 ounces at a time, until gas is passed. Colostomies in continuity, which often are not completely obstructed, and the clamped ends of the bowel in obstruction resection operations are not opened for twenty-four hours, when the same procedure is carried out.

In introducing a catheter into the bowel for a gas vent, a piece of the bowel wall is brought out onto the skin, the abdominal

\* David, V. C., and Gilchrist, R. K. The complicating effects of diverticulitis of the colon upon abdominal surgery and especially upon surgery of the large bowel. *Ann. Surg.*, 107: 801 (May) 1938.

wall is closed about it, the iodoform gauze and zinc oxide dressing is applied, and then the catheter is inserted into the bowel. This insures immediate decompression of the bowel without danger of soiling the peritoneum or abdominal incision.

The proper after-care of a colostomy is most important for the patient's comfort. Colostomies in the cecum or right side of the colon are much more difficult to handle due to the liquid content of the bowel. As most colostomies are on the left side of the colon and the feces are semi-solid, a system of care can be worked out so the patient does not lose more than one-half hour a day in the management of his colostomy. The diet is arranged so that the patient has slightly constipated movements. After breakfast the patient lies in a semi-reclining position, as in the bathtub. He threads an 18 French catheter through a baby bottle nipple so that the end of the catheter protrudes through the sucking end of the nipple for about 4 inches. The vaselined catheter is inserted into the colostomy followed by the nipple up to the flared out portion. This acts as a valve which is usually water tight.

A one and a half pint enema of plain cool water is now taken. The catheter is withdrawn, the patient sits up, has his bowel movement into a basin. Following the enema the colostomy is surrounded by vaseline gauze, dry gauze covers that, and a light elastic girdle is pulled up over the dressing. These girdles can be purchased for two dollars and are made by Bauer and Black. If the patient can arrange his diet to avoid diarrhea he will be free of bowel movements for twenty-four hours and can carry on his work as any normal individual. This procedure eliminates complicated apparatus and, when mastered, robs a colostomy of many of its disadvantages.

The mortality of colostomy is not negligible and is concerned with the pulmonary and vascular complications incident to age and carcinoma as well as to the occasional local complications, as wound infection, death of the colostomied bowel because of insufficient blood supply, ileus due to adherence of loops of small bowel to the colostomy wound, and peritonitis from technical errors or perforation of diverticula proximal to the colostomy.



# CECOSTOMY—INDICATIONS AND TECHNIQUE

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THE basis of this discussion is an analysis of the histories of ninety-six patients upon whom the author has performed cecostomy for either acute or chronic obstruction of the colon during the last twenty years. Study of these cases has been of unusual interest of the chronicle of the procedures carried out really is the history of the evolution of surgical operations upon the colon during this period.

The principle of decompression of obstructed lumina in various parts of the body has long been known. The earliest application was in decompression of the urinary bladder distended as a result of obstruction of the urethra. The extent and the degree of the pathologic and biochemical changes which inevitably accompany the obstruction of all hollow tubes in the human organism has been but slowly and as yet probably quite inadequately recognized. It is in the application of this principle in the treatment of acute obstruction of the colon that a blind cecostomy becomes an invaluable procedure. By a blind cecostomy is meant a cecostomy which is performed without a coincident exploratory laparotomy. The administration of a barium enema prior to the operation will in most instances localize the obstruction.

That the principle of decompression finds complete expression in blind cecostomy is substantiated by the fact that in this series there were thirty-three instances of acute obstruction of the colon which were submitted to a blind cecostomy, with but two deaths from obstruction, a mortality of 6 per cent, which is unusually low in any group of cases suffering acute intestinal obstruction. Following are the details of patients who failed to recover from the

obstruction: (1) a male, aged 74, obstructed for eight days, who died of peritonitis; (2) a female, aged 56, whose cecum was so distended that gangrenous patches were present, one of which perforated during the operation. A third patient died some weeks following the cecostomy, from inanition due to very extensive local disease with multiple metastases.

It thus becomes obvious that as a simple safety measure a blind cecostomy offers an admirable solution of the emergency resulting from an acute obstruction of the large bowel. It is felt that if this procedure fails to save the patient from the disasters of obstruction, no other operative procedure would have succeeded. The details of the three operative deaths cited above would support this contention.

The lesions for which cecostomy has been carried out in this group of patients are shown in Table 1, and provide an interesting comment on our therapy during this period.

TABLE 1

Carcinoma of the colon.....	74
Diverticulitis of the sigmoid.....	8
Sigmoid obstruction due to band.....	2
Volvulus of the cecum.....	1
Perforated appendix.....	2
Bullet wound colon.....	1
Colitis, idiopathic.....	2
Colitis, tuberculous.....	1
Benign tumor with intussusception...	2
Gastrojejunalocolic fistula.....	3
Total number of patients having cecostomy.....	96

It becomes obvious from this table that cecostomy is most useful in the malignant lesions of the colon. That it is valuable in this group means that its value lies in the relief of obstruction of the colon, either acute or chronic.

The distribution of the carcinomata in the colon for which this procedure was carried out is shown in Table II.

TABLE II  
DISTRIBUTION OF CARCINOMATA

Ascending colon	1
Transverse colon	8
Descending colon	9
Sigmoid colon	40
Rectum	7

A most valuable observation was made in one case, where the obstruction of the transverse colon was due to an intussusception of benign submucous lipoma. The cecostomy adequately relieved the abdominal distention and an abundant fecal discharge came from the cecal stoma. Despite this the patient suffered a persistence of the cramp-like abdominal pain. The significance of the relief of the obstruction without coincident relief of the crampy abdominal pain was not appreciated until a laparotomy was performed. We experienced the same phenomenon in a second case, and, correctly interpreting it, were able to proceed with the second stage of the operation as soon as the abdominal distention and the biochemical upset accompanying the obstruction was relieved. This is important with such a diagnosis, as undue delay makes the second stage of the operation more hazardous because of the edema and potential infection which persists about the intussusception.

While only three deaths occurred when a blind cecostomy was performed, five died when the cecostomy was coincident with a laparotomy. These five patients died of peritonitis. This is ample evidence of the rationality of the aphorism, "In all abdominal emergency operations, carry out only the most simple and atraumatic procedure directed solely to saving life, dealing only with the cause of the emergency." It might be said, in the incidence of a carcinoma of the sigmoid accompanied by acute obstruction, that the neoplasm of the colon was the cause of the emergency. This we question. The carcinoma was present for many weeks, with very

slight disturbance to its host. However, the onset of obstruction rapidly creates a new symptomatology as a result of the associated pathologic and biochemical changes. This rapidly changing clinical picture causes the patient to seek aid: therefore the obstruction creates the emergency.

A second aphorism is worthy of remembrance in acute abdominal disease: "Assess the clinical picture carefully in order to ascertain the rôle which the various factors contribute in creating the emergency." One would defer operation for carcinoma of the breast in a patient who when first seen was also suffering from acute appendicitis. This latter disease created the emergency, and must be dealt with adequately as a primary maneuver. With similar logic, one must defer operation on a carcinoma of the colon until the obstruction is adequately relieved. Granted that an accurate diagnosis of acute obstruction of the colon may be arrived at, it is submitted that a blind cecostomy is the most simple, safe and satisfactory primary procedure which will adequately solve the problem.

In addition to the pitfall where the chronic obstruction was due to the intussusception of a submucous lipoma, we have encountered a second lesion of the large bowel in which a blind cecostomy alone would be inadequate to control the emergency. We refer to a volvulus of the sigmoid colon. Our practice of using x-ray examination with a barium enema as a diagnostic aid will, if correctly interpreted, lead to an accurate diagnosis of this lesion. In the x-ray examination the great mass of the barium in the colon lies in the right upper quadrant. This observation, made in our department of radiology, has been reported by Hall.<sup>1</sup> With this diagnosis, the need for a laparotomy is obvious, but a coincident cecostomy of the type shown in Figure 3 is of real value in completing the decompression of the colon after the volvulus is adequately dealt with. The coincident laparotomy and cecostomy do not carry the potential danger of peritonitis, as is the case where the obstruction is due to

an ulceration carcinoma with associated edema.

Occasions arise, however, when one is confronted with the necessity of making the diagnosis of intestinal obstruction in a very ill patient suffering from ill-defined, bizarre abdominal systems, under circumstances where all the physical aids to diagnosis such as the x-ray and other laboratory facilities are not available. The diagnosis of intestinal obstruction can usually be made. The site and cause are often difficult to determine. If the obstruction be inflammatory, the appendix is the most common offending organ. If the site of the obstruction be in the small bowel, and the common hernial sites are eliminated, an exploratory laparotomy is essential. If the site be in the colon, and volvulus of the sigmoid can be eliminated, an exploratory laparotomy is highly undesirable. This is made evident by this study, as in this group of seventy-four cases of carcinoma of the colon accompanied by obstruction there were twenty-two deaths, but only eight of these could be attributed to the phenomena accompanying obstruction and only three of these died following a blind cecostomy. Five died when the cecostomy was accompanied by an exploratory laparotomy, and in each instance death was due to peritonitis. The source of the peritonitis we believe to be infection in and about the edematous, obstructed bowel wall. The trauma incidental to the exploration, even though gently carried out, is sufficient to break the barrier and release the infection. It is very similar to the waterproof qualities of a tent in a rainstorm. If a finger touches the inside of the tent, a break develops. We have been impressed with the fact that patients suffering from obstruction of the colon tolerate even the most simple operative procedures very badly. The incidence of streptococci in and about the edematous, obstructed bowel has been admirably shown by Garlock and Seley,<sup>2</sup> where cultures taken from the various sites about the lesion yielded a high incidence of hemolytic streptococci. Their suggestion to

bring such patients under control by sulphyridine before operation would appear to be very sound.

It thus becomes obvious that in circumstances where facilities are such that one is unable to arrive at an accurate localization of the obstructing lesion, the operative procedure must not only relieve the obstruction, but do so without adding any new element of danger such as accompanies the exploratory laparotomy when the obstruction is due to a carcinoma of the colon. We have shown a high incidence of peritonitis as an accompaniment of this procedure.

Under such circumstances our method of procedure is to operate with a spinal anesthetic and explore the abdomen through a McBurney split muscle incision. The cecum and terminal ileum are located. If the terminal ileum is not dilated, then the obstruction is in the small bowel, and a paramedian incision is made. No harm has been done, and but a few minutes have been consumed by making the McBurney incision. If, on the other hand, the cecum and terminal ileum are distended, the site of the obstruction is distal to the cecum and the obstruction will be relieved by a blind cecostomy without any of the increased hazards which would have accompanied a coincident laparotomy. It has been our custom to bring out a piece of cecum, which bulges into a circular mass approximately 1 inch in diameter. This segment of cecum is fastened to the skin with four interrupted catgut sutures. Failure to sew the cecum to the skin is often followed by a retraction of the cecum to a below-skin level. This renders the procedure less efficient, and is almost invariably accompanied by infection of the abdominal wall. The abdominal wound is closed about the protruding piece of cecum with a few interrupted catgut sutures. The details of this procedure are illustrated in Figure 1.

No attempt at an elaborate closure of the abdominal wall is made at this time, as we recognize a second operation will be necessary to close the cecostomy, and at

this time the abdominal wall may be adequately repaired. After an experience which involves many types of cecostomy

instillation of oil into the cecum by means of a small rubber catheter. Because it is cheap, efficient and readily available, we



FIG. 1. Position at which the portion of cecal wall is brought out in the right iliac fossa. The cecum is sutured to the skin by four interrupted catgut sutures. The incision is closed above and below the bulging portion of cecum. The opening in the cecum made with the actual cautery of such proportion in relation to the cecum as illustrated. This opening is placed at right angles to the long axis of the bowel.

operations designed to obviate the necessity for subsequent closure, we believe that the efficiency of the procedure here described, where a mucocutaneous fistula is established, provides so much more efficient decompression as to justify the additional operation necessary for its closure. We are insistent that no sutures be placed in the bowel except those uniting it to the skin. To suture the bowel to the subcutaneous structures is to invite infection of the abdominal wound.

The cecum is not opened for twelve to twenty-four hours following the operation. During this time the biochemical upset is corrected by the administration of glucose, salt, water and blood as indicated. It is amazing how much such patients improve during this period, even though the obstruction is not relieved.

The cecum is opened with the actual cautery. The incision is placed at right angles to the long axis of the bowel. One rarely has to tie any blood vessel in the bowel wall, although provision should be made to do this at the time the cecum is opened. We then immediately begin the

use raw linseed paint oil, injecting 3 to 4 ounces two to four times in the twenty-four hours, the amount and interval depending upon the degree of return of the oil through the cecostomy, which in turn is in direct ratio to the completeness of the obstruction. As the edema about the carcinoma subsides, the oil appears at the rectum, and then saline irrigations are carried out through the cecostomy and through the rectum. This maneuver, together with a low residue diet, is efficient in a large percentage of cases in keeping the colon empty and permitting the subsidence of the edema in the bowel wall and about the tumor.

Because we plan later to repair the abdominal wall, these patients are allowed to be up and about the ward in forty-eight to seventy-two hours after the operation. This, we believe, is a real asset, as the general muscle tone and exercise tolerance is maintained during the preparation, and the patient is thus much better able to withstand the next operative procedure.

How long should the interval be between the cecostomy and the resection of the

obstructing lesion itself? This question is answered by an analysis of the deaths which have occurred after this second stage. There were thirteen deaths in this group where, although the cecostomy was effective in relieving the acute obstruction, the patient succumbed following resection of the growth. In all but two instances, death resulted from infection.

In reading the histories of these cases, one is impressed by the repetition of the statement in the operative note: "Bowel wall still shows edema," or "Bowel contains fecal content." These statements are susceptible of two interpretations: first, the interval between the cecostomy and the second stage was too short to permit adequate preparation; or the obstruction was so nearly complete that some additional procedure was necessary to enable the bowel to remain empty and free from edema. In no instance should the resection be undertaken less than two weeks after the cecostomy. If the cecum at the time the cecostomy is performed shows evidence of gross edema, an interval of at least three, and preferably four weeks should elapse between the two stages.

Even with the most painstaking and apparently adequate preparation, when the abdomen is opened for the second stage, one is occasionally chagrined to find residual edema in the bowel wall and about the growth. Under such circumstances one should never attempt any form of anastomosis in continuity. Rankin's<sup>3</sup> obstructive resection of the Mikulicz type may be used. If, however, the lesion be in the left colon, we believe there should be an additional operative stage, and, despite a limited experience, we are most favorably impressed with Devine's<sup>4</sup> defunctioning transverse colostomy. This permits of the most adequate preparation of the distal colon.

If during an operative procedure the colon be involved or wounded, and one wishes to provide a safety valve as a temporary procedure, the use of a Pezzer catheter witzelled into the cecum, as

illustrated in Figure 2, is an admirable procedure. This may be carried out through the laparotomy wound. This maneuver permits the escape of gas and fluid content of the cecum, preventing distention and is worthy of greater recognition than is generally accorded it. Witzelling the catheter where it lies between the cecum and parietal peritoneum, enable the catheter to be cut off at the skin level when the need for the cecostomy is past. The distal fragment will be passed per rectum and the fistula will heal readily. We have used this type of cecostomy in cases of gastrojejuno-colic fistula, but the rod colostomy of the ascending colon, as suggested by Damon Pfeiffer<sup>5</sup> of Philadelphia is a more efficient and most valuable procedure.

In retrospect, and with the perspective of twenty years in the material presented by these cases histories, one is more and more impressed with a few simple fundamental and obvious truths in regard to obstruction of the colon, particularly when the obstructive lesion be carcinoma: firstly, our operative therapy in cases of acute obstruction must aim only at decompression of the colon, this to be achieved with the minimum of intraperitoneal manipulation; second, the colon must be kept relatively empty by non-residue diets and irrigations. This must be kept up for from two to four weeks, in order to permit the disappearance of the edema in the bowel wall and about the tumor; third, the biochemical balance of fluids and salts must be restored and maintained. The value of the proper proportion of glucose in saline and glucose in distilled water has been adequately presented by Collier and Maddock.

These three fundamental truths seem so obvious that stating them, much less repeating them, would seem superfluous, and yet how often have patients been sacrificed because of failure to completely and adequately grasp their import. In the presence of acute obstruction of the colon, a blind cecostomy fulfills adequately and simply the requirements of the operative



procedure, and it is in dealing with this problem that we have, in a blind cecostomy, a safe, simple and satisfactory

not entirely relieved, or if the bowel is not adequately empty of feces, this is not necessarily a condemnation of the value

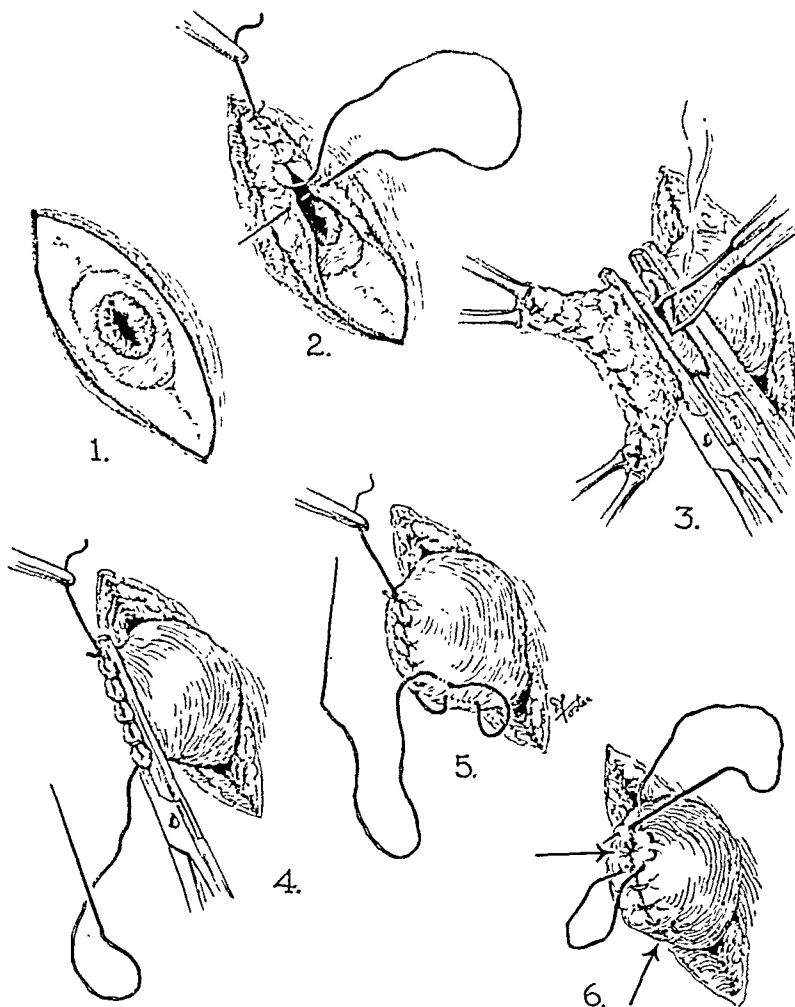


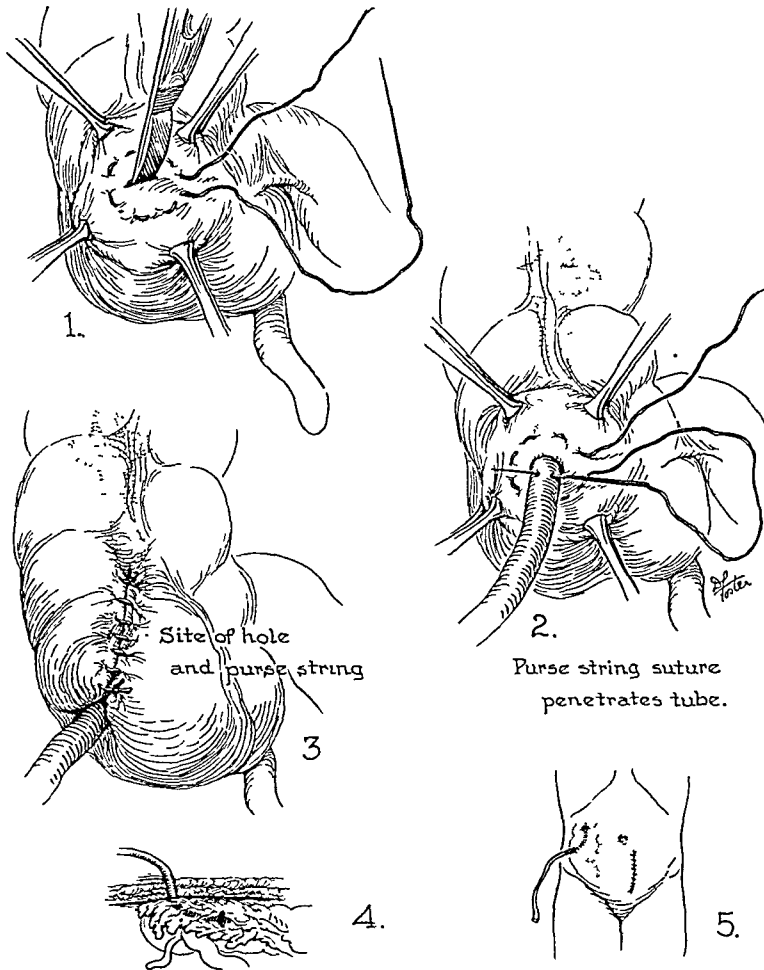
FIG. 2. Method of closing cecostomy. 1, cecostomy stoma, together with surrounding portion of cecum and skin scar isolated by an elliptical incision, which is carried down to the aponeurosis of the external oblique. 2, oversewing of this ellipse of skin, which serves to close the cecostomy stoma. The cecum is then mobilized and brought farther out of the wound, in order that the skin and stoma may be excised. This is accomplished by putting on three Kocher hemostats, leaving two and removing the third with the skin and stoma by means of the actual cautery. The more distal of the two remaining hemostats is removed, and the frill left is oversewn as shown in 4. A second row of sutures completes the closure. The method of closing the proximal and distal corners is shown in 5 and 6. The infolding stitch in 5 is efficient in burying the distal corner and the purse-string effectively closes the proximal corner. Between 2 and 3, gloves and instruments are changed, and after 6 the abdominal wall is smeared with BIPP and closed in layers with interrupted sutures.

method of combatting the emergency. If, when the second stage of the operative procedure is undertaken, the edema in the bowel wall or about the growth is

of the cecostomy, but evidence that following the relief of the acute emergency, further and more efficient operative means should be employed to secure an empty

bowel free from edema. The Devine colostomy does just this, and probably as experience increases, will become the sec-

tional step would entail two further operative procedures—first, excision of the growth, with anastomosis, and second,



Tube pulled through omentum which is placed between cecum and parietal peritoneum.

Tube brought through stab wound—abdominal wall.

FIG. 3. Technique of cecostomy coincident with laparotomy. 1, insertion of a purse-string with the cecum held up by four Allis forceps. This prevents escape of fecal contents while an opening is made with a knife in the middle of the area outlined by the purse-string. Through this opening a Pezzer catheter is inserted for 2 inches, and is held at this level by including the catheter in the purse-string suture, as shown in 2. 3, the bowel oversewn proximal and distal to the insertion of the tube. The catheter is then brought through the omentum, which lies interposed between the cecum and parietal peritoneum. The catheter is then brought out through the abdominal wall at McBurney's point by means of a stab wound. These last two maneuvers are shown in 4 and 5.

ond operative procedure when the lesion responsible for the acute obstruction is a carcinoma in the left large bowel. This should be seriously considered in all cases where saline does not run through the colon freely during the irrigations. This addi-

coincident closure of the cecostomy and colostomy.

The principle of multiple stage procedures is sound. We have been slow to appreciate and apply this principle, which has contributed so much to the safety and

efficiency of surgical operations upon the colon. That multiple stage procedures are time-consuming is no valid argument against their use. The procedures are much shorter than eternity, which may be the alternative time to which we condemn the patient.

How long should be the interval between resection of the obstructing lesion and the closure of the cecostomy? In only five of the ninety-six cases was the discharge from the cecostomy so insignificant that the patient elected to carry on without further operation. The shortest interval in this series was six weeks. It has been considered wise to defer closure for three months, in order to permit a complete subsidence of all the inflammatory reaction about the anastomosis. If, however, there is continuous gross soiling, which is most infrequent, with great discomfort to the patient, the cecostomy may be closed any time after six weeks, providing x-ray examination with a barium enema shows a good lumen at the site of the anastomosis, thus ensuring a disappearance of any obstruction from postoperative edema.

The details of the dissection which we carry out in closing the cecostomy are adequately presented in Figure 3. In most instances this can be carried out extra-peritoneally. One need have no concern, however, if the peritoneal cavity be opened. Using the suggested technique which we have developed, there has been no case of peritonitis following closure. The incidence of infection in the abdominal wall has been negligible. The use of BIPP rubbed into the layers of the abdominal wall after excision of the scar tissue we believe to be of real value in preventing wound infection. If, when the bowel has been closed, as indicated in Figure 3, the peritoneal cavity has been opened, a continuous catgut suture closes the anterior peritoneal peritoneum. The internal oblique and trans-

versalis muscles, as well as the aponeurosis of the external oblique, are united with a few interrupted catgut sutures, the skin being loosely closed with a few widely separated interrupted silk sutures. The patient is allowed out of bed in ten days.

#### CONCLUSIONS

1. In acute obstruction of the colon, a blind cecostomy offers a safe, simple and satisfactory means of combating the emergency.

2. The technique of sewing the cecum to the skin ensures efficient drainage of the cecum with a minimum of wound infection.

3. The patient is able to be out of bed within forty-eight to seventy-two hours of the operation, and muscle tone and exercise tolerance are maintained during the preparation for the subsequent operative procedure.

4. A minimum interval of two weeks should elapse between the cecostomy and resection of the tumor, longer intervals being required in direct ratio to the degree of edema at the cecum.

5. If at the second operative stage, edema of the bowel wall be still present, this is not a condemnation of cecostomy, but an indication to defer resection and carry out a procedure to more efficiently defunction the colon.

6. Closure of the cecostomy should be deferred a minimum of six weeks, and preferably for three months following the resection.

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# LYMPHATIC DISTRIBUTION OF THE COLON AND RECTUM

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THE lymphatics of the entire gastrointestinal tract are so intimately interrelated that it becomes a rather tedious task for one to obtain a concise understanding of the lymphatic drainage of any one part without first surveying the lymphatics of the entire system. It will be necessary, therefore, in a discussion of the lymphatics of the colon and rectum to give, firstly, the general arrangement of the main groups of lymphatic glands in the abdominal and pelvic cavities and the ducts through which the lymph flows from the entire gastrointestinal tract to the cisterna chyli. Secondly, an attempt will be made to describe in detail the exact routes, so far as they are known, by which lymph flows from every subdivision of the large bowel to its final entrance into the main lymph channel. By this plan it is hoped that the reader may obtain a concise mental picture of the lymphatics of any given portion of the large gut independently of all other portions.

Originality is claimed only in the arrangement of the subject matter of this paper, and none whatsoever as concerns the material itself. Free use of statements and descriptions by a number of authors is made, and full credit given to each in a list of references at the end of the article.

## GENERAL ARRANGEMENT OF THE LYMPH GLANDS IN THE ABDOMEN PROPER

There are four main groups of lymph glands in the abdomen proper, all of which are concerned either directly or indirectly with the drainage of the colon and rectum. In accordance with their relation to the abdominal aorta, they can be called the pre-aortic, the para-aortic (right and left lumbar) and the retro-aortic lymph glands.

The first, or pre-aortic group, is composed of three main subgroups, namely, the celiac group, the superior mesenteric group, and the inferior mesenteric group.

The celiac group, situated around the celiac artery in the upper part of the posterior abdominal wall and related to the abdominal aorta, consists of a variable number of glands. This group of glands may be further subdivided into a number of smaller groups corresponding to the chief branches of the celiac artery and their branches. It will not be necessary to discuss these groups of glands, since they do not concern us particularly in this paper.

The superior mesenteric group of lymph glands lies along the main stem of the superior mesenteric artery, in the root of the mesentery of the small intestine. These glands receive afferents from the glands associated with the several branches of the superior mesenteric artery, and will be described more fully below.

The inferior mesenteric group of lymph glands is situated along the stem of the inferior mesenteric artery. The glands of this group receive afferents from the smaller glands associated with the branches of the inferior mesenteric artery.

In addition to these three main groups of pre-aortic lymph glands, many glands are found lying upon the anterior surface of the abdominal aorta which cannot be said to belong to any one of the three groups described above. They merely serve as connecting glands for all the aortic groups.

The chief groups of celiac and superior mesenteric lymph glands give origin to efferent lymph ducts which unite to form the common gastrointestinal (common intestinal) lymph trunk. This large duct thus formed empties into the cisterna

chyli, whence the lymph flows into the thoracic duct. The inferior mesenteric lymph glands are drained into the para-

brac, between the aorta on its left and the vena azygos on its right.

The retro-aortic glands lie behind the

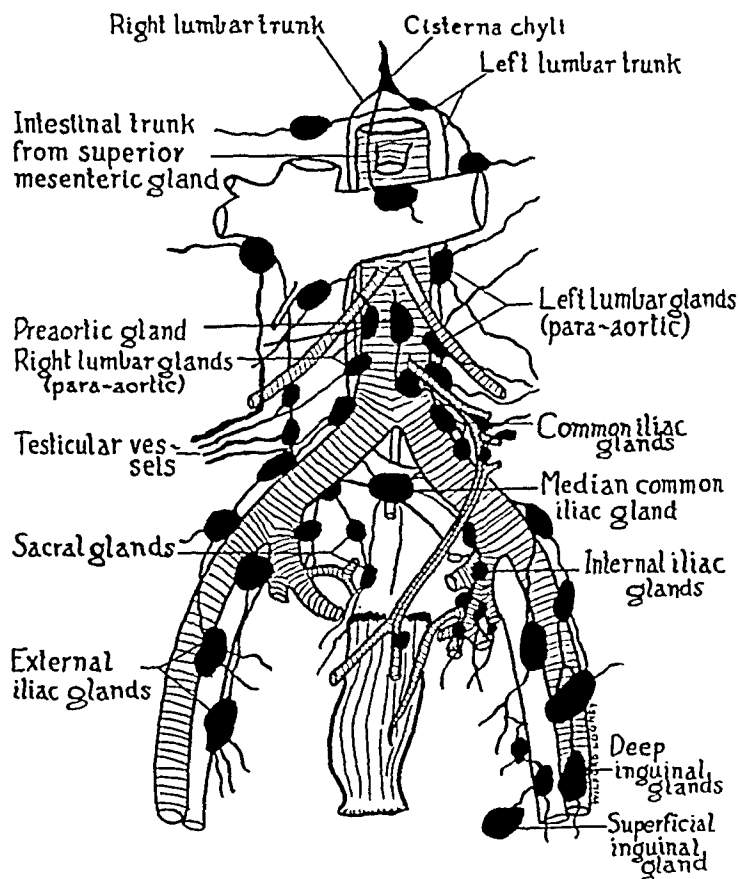


FIG. 1. Diagram of lymph vessels and glands of posterior abdominal wall and pelvis. (Modified from Cunningham.)

aortic (lumbar) glands, especially the left ones. From here the lymph is carried by the lumbar trunks to the cisterna chyli.

The para-aortic lymph glands are situated along either side of the abdominal aorta, being much more numerous on the left side than on the right. They are commonly known as the right and left lumbar lymph glands. Those on the right side of the aorta are found chiefly behind the inferior vena cava.

A common lymph trunk issues from each group of para-aortic (lumbar) glands, and receives the name of right or left lumbar trunk. According to some descriptions these two ducts unite to form the cisterna chyli. The latter structure is placed upon the bodies of the first two lumbar verte-

brae, between the aorta on its left and the vena azygos on its right. The retro-aortic glands lie behind the

#### LYMPH GLANDS OF THE PELVIS

Like the lymph glands of the abdominal cavity, the lymph glands of the pelvis can be divided according to their relations to the main blood vessels. Thus we find three main groups of glands in the pelvis, each of which is associated with one or other of the three large arteries of the pelvis: (1) external iliac lymph glands, continuing upward the inguinal lymph glands; (2) internal iliac lymph glands, found in the

pelvis proper; and (3) common iliac lymph glands which are the proper connecting links between the first two groups and the aortic lymph glands.

There are many subdivisions of these three groups of lymph glands, especially of the internal iliac group. The subgroups of the internal iliac group are named according to their association with the various branches of the internal iliac artery, and for our purpose require no further description.

One small group—the sacral lymph glands—is, however, important because of its intimate connection with the rectal lymphatics. The lymph glands comprising the sacral group lie in the hollow of the sacrum, and their efferents pass to the common iliac and aortic lymph glands.

The external iliac lymph glands form three chains—lateral, intermediate, and medial—which lie along the external iliac vessels, and receive lymph vessels chiefly from the inguinal lymph glands. Their efferents pass to the common iliac lymph glands.

The internal iliac lymph glands are situated along the trunks of the internal iliac arteries. As stated above, many subgroups are found in association with the several branches of the internal iliac artery and with the pelvic organs. The efferent vessels of the internal iliac lymph glands empty into the common iliac lymph glands.

The common iliac lymph glands are the direct continuation upward of the internal and external iliac lymph glands. Several subgroups of the common iliac glands have been described according to the relations of the glands to the common iliac vessels. The efferent ducts of the common iliac lymph glands join the para-aortic (lumbar lymph glands).

#### LYMPHATICS OF THE CECUM AND APPENDIX

The lymphatic drainage of the cecum and appendix is accomplished by three sets of collecting vessels, namely: (1) an

anterior cecal group; (2) a posterior cecal group; and (3) an appendicular group.

The anterior cecal lymph channels begin

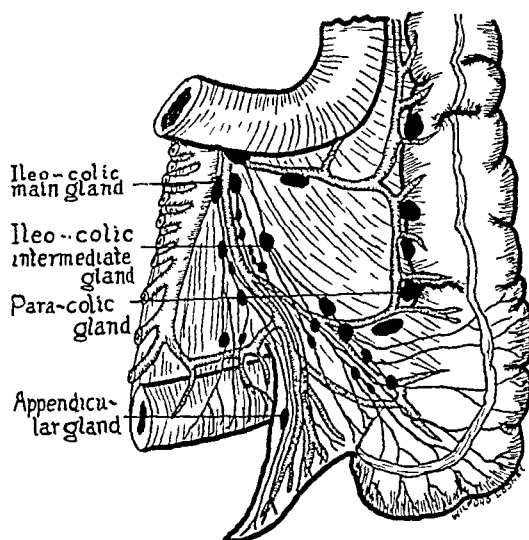


FIG. 2. Lymph vessels and glands of the cecum and appendix from behind. (Modified from Jamieson and Dobson; Cunningham.)

in the submucous coat of the cecum and drain all its anterior surface. After traversing one or two small nodes these ducts pass to the main group of ileocecal glands. From here the lymph passes through ducts to the superior mesenteric lymph nodes.

The posterior cecal lymphatics are very similar in their origin to the anterior. They drain the posterior surface of the cecum, and finally terminate, like the anterior ducts, in the ileocecal lymph glands and in the superior mesenteric lymph glands.

It is said that both sets of cecal lymphatics communicate freely with the lymphatics of the base of the appendix but not at all with the lymphatics of the rest of that organ.

The lymphatics of the vermiform appendix are especially well developed, and subserve an important rôle in infections of the appendicular region. The small lymphatic capillaries of the appendix begin in the submucous and peritoneal coats and communicate freely with one another through the muscular coat. Collecting trunks from these capillaries are formed

which enter the mesoappendix and follow the course of the appendicular vessels.

The main lymph trunks of the appendix end in several groups of glands:

(c) It is stated that ducts from the appendix join the lymphatics of the ovary. According to some observers this can occur only when the mesoappendix is prolonged

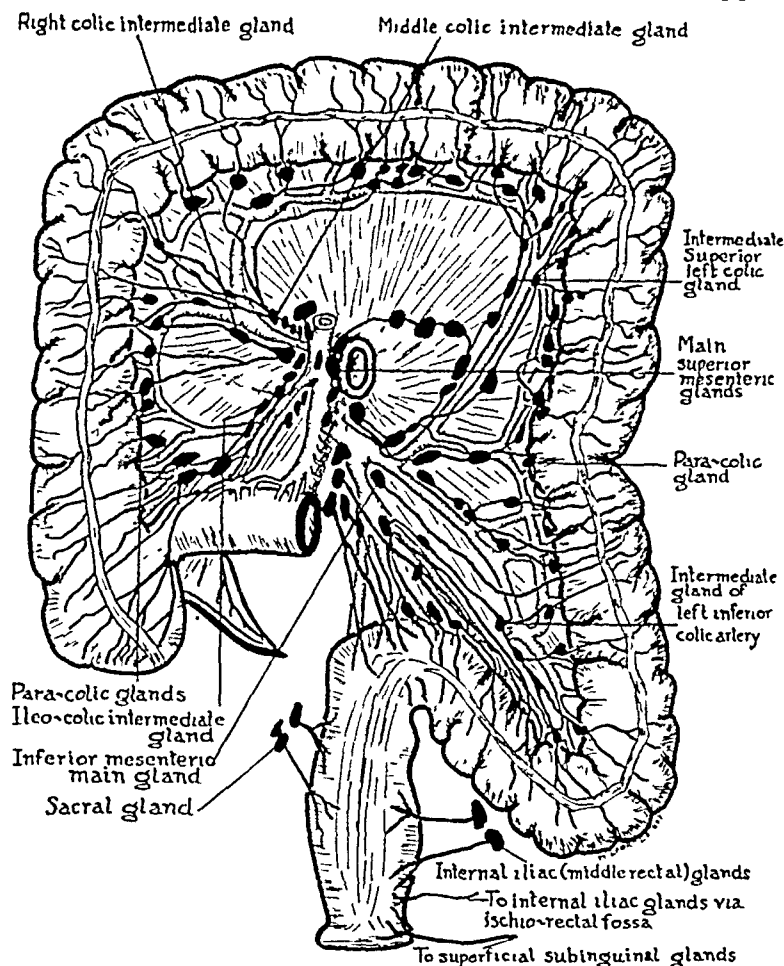


FIG. 3. Lymph vessels and glands of the large intestine. (Modified from Jamieson and Dobson; Cunningham.)

(a) Into the appendicular glands (ceco-appendicular). These are two or three small glands which lie in the mesoappendix, in the angle between the appendix and cecum, and behind the terminal part of the ileum. The ducts from these glands join the ileocecal glands which lie along the course of the ileocecal artery. From here the lymph passes to the superior mesenteric lymph glands.

(b) Directly into the ileocecal glands, which are, in their turn, connected with the superior mesenteric lymph glands. The ileocecal glands lie along the course of the ileocecal artery.

to the broad ligament. The prolongation of the mesoappendix, when it occurs, constitutes Clado's ligament.

Tixier and Viannay pointed out that the appendix has a double insertion—cecal by its root, and ileal by its mesentery. Hence, the lymphatics of the base of the appendix follow those of the cecum, while the ducts of the rest of the appendix pass more directly to the superior mesenteric lymph glands. Practically all the ducts of the appendix run behind the terminal part of the ileum.

It has been stated that the lymphatics of the appendix may extend to the pleura

through the lymphatics of the peritoneum which connect with the lymphatics of the pleura through the diaphragm (Campbell).

Communications have been described as existing between the appendicular lymphatics and those of the broad ligament of the uterus as well as with the iliac glands. The more recent observations have failed, however, to confirm the existence of any direct connections with these structures, and pathologic conditions of the broad ligament and iliac glands associated with acute appendicitis may perhaps be due to the dissemination of the infection through the subperitoneal network by way of the so-called appendiculo-ovarian (Clado's) ligament (Piersol).

#### LYMPHATICS OF THE COLON AND RECTUM

There are comparatively few lymph glands along the ascending colon. When present, they lie along the medial margin of this portion of the large gut and receive some of the lymph channels from its anterior and posterior surfaces. From these paracolic lymph glands, ducts pass along the course of the right colic artery, communicating freely with the right colic lymph glands, and, finally, terminating in the superior mesenteric group of lymph glands.

The lymphatics of the right flexure of the colon and the right two-thirds of the transverse colon, after traversing the paracolic (or mesocolic) glands situated along the upper border of the transverse colon and between the two layers of the transverse mesocolon, pass to glands associated with the branches of the middle colic vessels. From the middle colic lymph glands the lymph is carried by channels to the superior mesenteric lymph glands.

In the area of distribution of the inferior mesenteric artery—left one-third of transverse colon, left flexure, descending colon, pelvic colon, and upper portion of rectum—the lymphatics of the large bowel pass to the epicolic and paracolic lymph glands. From these glands ducts pass into the inferior mesenteric lymph glands, situated

along the stem of the inferior mesenteric artery. The lymphatics of the inferior mesenteric group of glands join the left para-aortic (lumbar) lymph glands.

The lymphatic drainage of the left one-third of the transverse colon and the left flexure, because, of its peculiar arrangement, requires special mention. These lymph vessels are not "direct vessels" beyond the intermediate gland group. One set of lymph vessels follows the course of the inferior mesenteric vein to the superior mesenteric group of lymph glands. It is stated that a few small peritoneal vessels from the left flexure of the colon run upward in the greater omentum and thence through the gastrosplenic ligament to the lymph glands situated near the hilum of the spleen (Cunningham).

#### LYMPHATICS OF THE RECTUM AND ANUS

There are three lymphatic zones of the rectum and anus: (1) An inferior zone, corresponding to the anal integument, in which the capillary networks, both superficial and deep, are extremely abundant, and from which from three to five collecting vessels on either side pass to the inguinal region and end in the medial superficial inguinal nodes. (2) A middle zone, corresponding to the transition zone of the epithelium—that is, with the mucous membrane below the columns of Morgagni. Here the network is coarse, and has its meshes arranged vertically; its ducts drain partly into nodes situated along the inferior and middle hemorrhoidal arteries, and partly pass to the nodes of the mesorectum, situated along the superior hemorrhoidal artery and known as the anorectal nodes. (3) The superior zone corresponds to the remainder of the rectal mucous membrane, and contains a rich network whose collecting vessels pass to the anorectal glands, and thence along the superior hemorrhoidal artery to the mesocolic and inferior mesenteric nodes (Morris).

The above description will serve to give the reader a rather definite notion of the



lymphatic drainage of the rectum and anus, but sight must not be lost of the fact that many of the lymphatic channels from especially the middle portion of the rectum join directly with the internal iliac lymph glands and with the sacral glands. From these nodes the lymph passes to the common iliac and aortic (lumbar) lymph glands.

#### SUMMARY

We may state that the lymphatic ducts of the appendix, cecum, ascending colon, right colic flexure, and right two-thirds of the transverse colon follow in general the distribution of the superior mesenteric artery and end in the superior mesenteric lymph nodes, whence the lymph passes through the gastrointestinal (common intestinal) trunk to the cisterna chyli. Lymph from at least a portion of the left flexure of the colon passes to the superior mesen-

teric lymph glands and to the lymph glands of the hilum of the spleen. The lymph drainage of the descending colon, pelvic colon, and most of the rectum is through the inferior mesenteric and iliac glands and thence to the left lumbar glands. Lymph from the lower part of the anal canal passes by way of vessels which terminate in the superficial inguinal lymph nodes.

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# THE MANAGEMENT OF A PERMANENT COLOSTOMY\*

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PATIENTS who have permanent colostomies vary widely in their way of life depending upon their personalities and upon the system of colostomy management employed. Many of these patients have found that the pattern of their lives have been changed only in small detail. These people have resumed their occupations, engaged in every business and profession, and have found their colostomies a relatively minor handicap. Often their deformity has been unknown not only to their casual acquaintances but even to their business associates and friends. These patients have in large measure enjoyed almost complete economic and social rehabilitation.

This encouraging picture is not, however, descriptive of all colostomy patients, for there are many others who lead narrow, secluded lives, lives which center and revolve about the colostomy and its difficulties. These people are constantly fearful of an unexpected movement which will embarrass and inconvenience them and betray their misfortune to all about them. Some few may rightfully attribute their unfortunate state to the location of the colostomies in the right side of the colon, where the stool is liquid and where control by any means is extremely difficult and undependable. However most permanent colostomies are today located in the left side of the colon where the stool is relatively solid and where adequate control may by proper procedures be readily established, thus freeing the patient from constant apprehension and anxiety, and permitting him to be restored to a useful and comparatively comfortable existence.

Widely differing methods of colostomy control have been used by physicians. The

commonest method is the use of one of the many different types of colostomy bags. Some physicians employ absorbent dressings which are changed as often as necessary. Occasionally, patients are advised to purge themselves drastically one day, and take advantage of the resultant period of constipation. Many and varied pressure devices have been employed in an attempt to control the colostomy by external pressure, and not a few gadgets have been used to "cork up" the colostomy for variable periods. Some physicians have emphasized the importance of diet, medication, formation of a regular bowel habit, and of irrigations in the proper regulation of a colostomy.

At the Mt. Sinai Hospital a régime for the care of colostomy patients has been established. It has proved eminently successful in coping with the difficulties presented by abdominal artificial ani. This routine is based largely on the fact that most of our permanent colostomies are left sided, so that the patients can be made to have formed stool in their colons. This routine will be described under six headings:

1. Diet
2. Medication
3. Irrigation and training
4. Use of appliances and dressings
5. Care of the skin
6. General measures.

## I. DIET

The object of the diet is to render the patient so very constipated that evacuation will occur only upon irrigation. The diet should result in a stool which is hard, dry, formed and scant in amounts. The

\* From the Surgical Service of Dr. Ralph Colp, Mt. Sinai Hospital, New York City.

diet which is most successful in accomplishing this is a bland, low residue diet with low fat and high carbohydrate components.

A bland diet must be non-stimulating and non-irritating. Condiments, strong alcoholic drinks, iced drinks and charged water are not permitted and any food which may have a laxative action such as prunes or apricots should be avoided. No foods which produce bulk in the stool should be taken. The vegetables and fruits which are allowed should be well cooked to render them as soft as possible, and initially, these should be puréed. It is often expedient to use the strained vegetables and fruits which are sold in jars for use in infant feeding. Indigestible foods, which tend to pass through the intestinal tract unchanged, such as berries and the tendinous parts of meat, should never be eaten.

The low fat diet has been found to be most constipating. Cattell<sup>1,2</sup> starts his patients with a bland low fat diet and later increases the amount of fats. Hesse<sup>3</sup> believes that a high fat diet increases intestinal action and also limits fats. Schmieden<sup>4</sup> employs a low fat diet until satisfactory function is obtained. DuBois<sup>5,6</sup> suggests that at first all foods containing considerable fat be avoided. Some difficulty may be encountered in giving meals with sufficiently high caloric value so that patients may regain weight lost during operative procedures and convalescence. However, the judicious use of chocolate, cocoa, and jellies and drinks sweetened with sugar, will increase caloric intake so that a satisfactory gain in weight may occur if other factors are conducive to this.

We do not limit the fluid intake although certain authors<sup>3,4</sup> do this. Rarely limitation of fluid may be necessary. It is certainly true, however, that a smaller food intake results in a smaller amount of stool, and for this reason, DuBois recommends abstemiousness. This too is rarely necessary but may be attempted in obstinate cases which do not respond favorably to the usual methods of control.

Meals should be taken at regular hours, eaten slowly, and no food should be permitted between meals. The patient who nibbles at food throughout the day is often the one who frequently has small movements in the dressings. Whenever practical, water should be taken only at meal time as otherwise it may serve to incite the gastrocolic reflex and result in movement of stool or passage of gas.

#### THE INITIAL COLOSTOMY DIET

The Following Foods Are Recommended:

*Vegetables*—Cooked vegetables with soft cellulose (potatoes, carrots, squash).

Vegetable purée (peas, beets, string beans, tomatoes, asparagus tips).

*Fruits*—Cooked fruits with skins and seeds removed (apple, pear, peach).

Strained juices (orange, grapefruit, pineapple, tomato).

*Breads and Cereal*—White bread and plain crackers.

Cooked fine cereals and gruels (rice, cream of wheat, patent barley).

Dry ready to serve cereals without bran (corn flakes, puffed wheat).

Spaghetti, noodles, macaroni.

Plain cake.

*Dairy Products*—All milk must be boiled.

Unfermented cheese, especially cottage cheese.

Small amounts of butter.

Eggs—boiled or poached.

*Meats*—Tender, well cooked meat, fish and chicken. Fat and tendinous parts should be avoided.

*Desserts*—Cake or fruit as above.

Clear fruit jelly.

Simple, bland desserts (cornstarch, chocolate or junket, tapioca pudding, custard, plain gelatin).

*Miscellaneous*—Creamed sauces, cocoa, chocolate, weak tea, caffeine-free coffee.

The Following Foods Should Be Avoided:

*Vegetables*—All vegetables except those listed above.

Any raw vegetable.

Irritating vegetables (onions, peppers, radishes).

Vegetables high in residue.

Vegetables which tend to cause gas (beans).

*Fruits*—Raw fruits.

Fruits high in indigestible cellulose (pineapple).

Fruits containing many seeds (berries).

*Breads and Cereals*—Whole grain breads (wholewheat and pumpernickel).

Cereals high in residue (bran cereals).

*Dairy Products*—Cream.

Fermented cheese.

*Meat*—Pork, veal or duck.

Skins of poultry.

Fatty and fibrous parts of meat.

*Miscellaneous*—Fried foods of any kind.

Jams.

Spices and condiments, highly seasoned or strongly salted foods.

Coffee, strong tea, charged water, alcoholic beverages.

A suggested diet follows:

#### *Breakfast*

Fruit juice or fruit as described

Well cooked cereal with boiled milk and sugar

Eggs

White bread or toast with butter or jelly

Caffeine-free coffee, or chocolate or cocoa

#### *Lunch*

Milk soup with strained vegetables or clear soup

Meat or cheese or eggs

Vegetables as listed

Custard or pudding or gelatin

White bread with butter or jelly

Cocoa or tea

#### *Dinner*

Tomato juice

Soup as above

Meat, fish or chicken

Boiled, baked or mashed potato

Puréed vegetables as listed

Cooked fruit or pudding

White bread with butter or jelly

Cocoa or tea

Shortly after the desired degree of constipation is obtained, other foods may be added. Only one new food should be added during one two-day period so that if a food produces loose movements it can readily be recognized. Patients vary greatly in the degree of irritability of their digestive tracts. Some will be constipated regardless of the food eaten and others will have a profuse diarrhea following the eating of a raw apple. In this regard, patients may be arbitrarily divided into three groups. The first group is comprised of patients who have been constipated all their lives and who remain so after operation. These patients may, after a time, eat anything without ill effect on the function of the artificial anus. The second and largest group is composed of those whose frequency of normal movement directly reflects the foods eaten. Here, obviously, proper diet will be quite important in attaining a marked degree of constipation. The third group includes individuals who normally have two or three bowel movements daily. These patients are moderately difficult to control and require meticulous dietetic management, augmented by proper medication in order to achieve successful colostomy control.

It behooves the physician, therefore, to classify the patient and to add foods with these facts in mind. The first usual addition is to allow the whole cooked vegetable instead of the purée. Subsequently, raw fruits with the skins and seeds removed, and a greater variety of vegetables are added. Uncooked milk is substituted for boiled milk and the fat content of the diet is increased by allowing more butter, cream and the fatty parts of meat. Fried foods are added last, if at all. The usual coffee is taken instead of caffeine-free coffee. Cooked sea foods are attempted quite late in the period of regulation. Foods such as cabbage, celery, poultry skins and others which have an irritating or bulky residue may only be permitted to those who classify as group one. Additions are made slowly until the patient is receiving the

greatest variety of foods that is compatible with a marked degree of constipation. The ultimate diet will naturally vary, depend-

times a day, it induces constipation and allays diarrhea. DuBois states that it tends to deodorize the stool. It occasionally

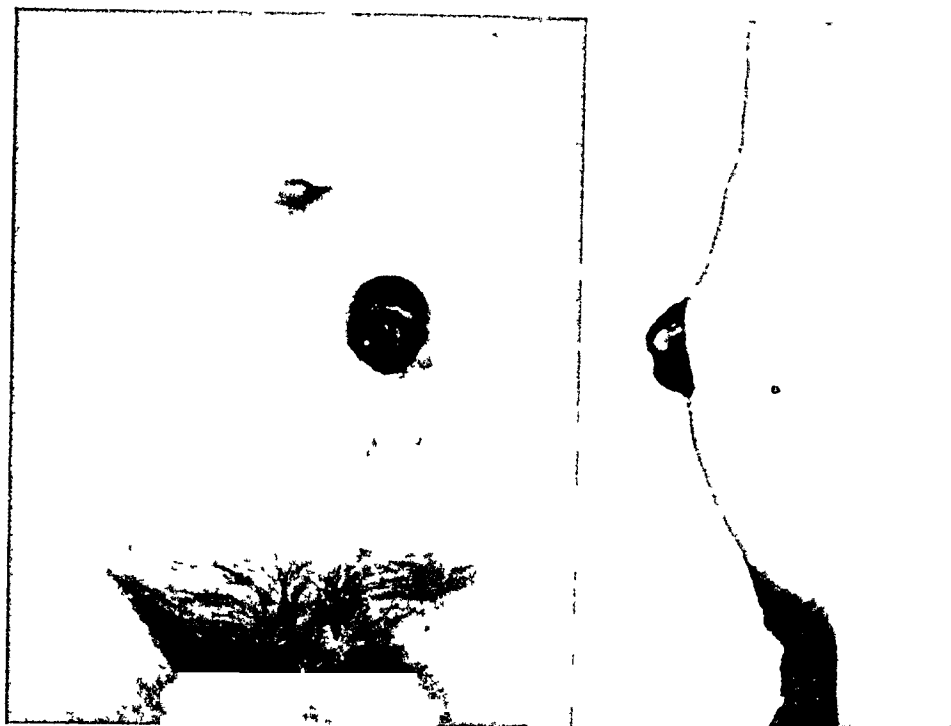


FIG. 1. A colostomy cared for by the methods described herewith. Note that despite the laxity of the abdomen and the presence of a contiguous large incision, there is no herniation about the stoma.

ing on whether the patient is in group one, two or three.

## 2. MEDICATION

Although the majority of colostomy patients do not need constipating medications, there are, however, certain patients who require them and are greatly benefited by their use. The patient with a transverse colostomy who despite careful attention to diet still has loose stools, may be greatly helped by the proper medicines. The nervous, high-strung individual often requires constipating medication and small doses of sedatives for successful regulation. The judicious use of drugs is indicated when patients are first attempting to constipate themselves. Finally, they may be temporarily necessary after a dietary indiscretion.

Bismuth subcarbonate is one of the most useful drugs. In doses of 15 to 60 gr., three

diminishes the amount of gas. Powdered kaolin, a somewhat less constipating medication, may occasionally be used along with, or instead of bismuth.

Opium is very often efficacious when other drugs fail, but it should be used over relatively short periods of time. It may be administered simultaneously with other medications. The two frequently used preparations are tincture of opium in doses of 5, 10, or 20 minims, three or four times daily, and paregoric in teaspoonful doses at like intervals. The amount of morphine administered is relatively small, the former containing  $\frac{1}{10}$  of a grain of morphine in each 10 minims, and the latter containing  $\frac{1}{40}$  of a grain of morphine to each 4 c.c.

Charcoal is a time honored remedy for excessive amounts of gas. Sollmann<sup>7</sup> claims that whereas freshly heated charcoal adsorbs gasses, moist charcoal does not

possess this quality and that it is, therefore, unsuccessful in the treatment of flatulence. Schmieden reports that it not only rids the

spent several hours with a colostomy patient suffering from diarrhea will need to be cautioned against the use of purgatives.



FIG. 2. A colostomy in a patient addicted to a colostomy bag. The colostomy was brought out through a small incision which was completely filled by the exteriorized colon. Note the hernia about the colostomy and the absence of hernia in the long rectus incision. The hernia conforms exactly in size to cup of the colostomy bag. The pressure marks of the cup may be seen. These peristomal herniae are caused by ischemia of the underlying muscles and fascia due to pressure of the cup, by the suction effect of the bag or by both. This hernia has since grown even larger.

patient of gas but also deodorizes the stools. Hesse speaks highly of animal charcoal for similar reasons. We have found that finely divided and dried vegetable charcoal occasionally reduces the amount of gas. It is administered in doses of 15 to 30 gr. three times a day.

The use of kerol, a patent medicine, to deodorize the excreta is recommended by Lockhart-Mummery,<sup>8</sup> Shedden,<sup>9</sup> and Best.<sup>10</sup> A capsule containing 3 minims is given daily before breakfast.

There are some who believe in controlling an artificial anus by having a so-called "stool day," every third day, by means of vigorous catharsis. Following this diarrhea, the patient remains constipated for a day or two. This method is mentioned only to be vehemently condemned. Laxatives and purgatives are but rarely needed and are not necessary in the proper management of a colostomy. Even such a mild lubricant as mineral oil should not be used. Constipation is the state we attempt to produce so that defecation of feces will occur every two or three days and then only under the stimulus of an irrigation. No one who has

Occasionally one sees left-sided colostomy patients who do not respond to the constipating diet and medications. These patients may be suspected of having so-called gastrogenous diarrhea due to achylia gastrica. Diagnosis is made, of course, by a fractional test meal. Rehfuß<sup>11</sup> states that even small amounts of hydrochloric acid will succeed in overcoming this diarrhea. The dilute hydrochloric acid may be used in liquid, capsule, or tablet form and is generally taken with meals. When it is employed in properly selected cases its effects are striking. A patient on a constipating régime who is having many loose movements will within one day after starting the acid medication, become markedly constipated.

It is recommended that those patients who require a strict constipating diet over long periods of time be given concentrated vitamins, especially D and B, to augment the scant vitamin content of the diet.

### 3. IRRIGATION AND TRAINING

Irrigations are of primary importance in colostomy management. In the literature

one finds scattered reports about a chronic colitis that occurs following long continued use of irrigations. This is not, however, the usual experience, for most observers see no ill effects from their long continued use. Binkley<sup>12</sup> has employed daily irrigations in colostomies for many years and has found this a most satisfactory method. Cattell, Smith<sup>13</sup> Bowman,<sup>14</sup> and others, employ irrigations routinely. We have had excellent results from the irrigation treatment and so far have never seen ill effects.

The object of the irrigation is to empty the colon thoroughly of its fecal content so that no movement will occur in the intervals between irrigations. The length of these intervals must be determined by trial and error. Patients who were chronically constipated prior to operation will often be able to allow two or three days between irrigations. This may also be true for those who are able to achieve a marked degree of constipation by means of diet and medication. Constipation in patients with an artificial anus has not been found to be detrimental to the general health. The average patient requires an irrigation about once in twenty-four hours.

The simplest possible technique is employed. An ordinary enema bag or can is equipped with a tube, a shut-off valve, a glass adapter and a 26 F. catheter. Warm tap water is used for the irrigation which may be given with the patient sitting, standing, or lying in bed. The enema can is placed about 3 feet above the level of the artificial anus, the catheter is inserted into the colostomy as far as it will go, and the water is allowed to flow in slowly. A large deep basin is held snugly against the abdomen just below the colostomy to catch whatever may run back along the catheter. Sometimes it is necessary to hold a piece of gauze or cotton tightly against the lumen of the bowel to prevent too much loss of water. When the patient feels quite full, the catheter is removed and the water and intestinal contents are expelled into the basin. When all the water and stool have seemingly been expelled, the entire proce-

duce is repeated once or several times until the return is clear. About ten to twenty minutes are allowed to elapse before the permanent dressing is applied because during this time fluid temporarily retained in the colon will be discharged. A small piece of gauze and a large thick cellucotton or cotton pad is placed over the stoma to absorb the fluid as it is expelled. Later the permanent dressing is applied. Further attention is usually not required for the ensuing twenty-four hours or longer periods, depending upon the patient.

This is the so-called "open" method of irrigation which we have found to be the best for routine use. With a little care and practice it can be performed with no soiling of the body, clothes, or room. The average time required is about forty-five minutes. The only parts of the apparatus requiring cleaning are the catheter and the basin. There is, however, a "closed" method of irrigation for which numerous devices have been invented. Best<sup>15</sup> employs a metal urinal which has a tube running into it near the handle and out through the mouth of the urinal. This tube is inserted into the artificial anus, the urinal is held firmly against the abdomen over the stoma, and the water is allowed to flow through the tube, wash out the colon and run back into the urinal. Binkley uses an excellent apparatus for closed irrigations. It consists of a bakelite cup which has a small opening for a catheter and a wide outlet which connects with a broad soft rubber tube. The cup is held in position over the stoma by an adjustable canvas belt. The apparatus can be used with the patient lying in bed or sitting on the toilet. The irrigating fluid is run into the colon through the catheter and the returning fluid and feces are expelled into the cup and conveyed through the wide rubber tube into a receptacle or into the toilet unseen by the patient. Binkley has found this method so satisfactory that he uses it routinely.

For the fastidious or sensitive patient, one or another of these appliances may be found very useful. The advantage of the

closed method lies solely in its esthetic appeal. Its disadvantages are: the apparatus itself must be cleaned, the irrigation takes longer, and the continuous irrigation with the catheter in place does not clean the bowel quite as well as the intermittent flushing and emptying.

There is a small percentage of patients who do not need to employ irrigations but are able to have a regular movement every morning and remain perfectly clean for the remainder of the day. Many more patients are able to have the regular movement but tend to have several very small movements during the day. Gibson<sup>16</sup> prefers irrigation to training for this reason. Lockhart-Mummery attempts to train his patients to have regular movements before inaugurating irrigation treatment. Schmieden and Hesse advocate training. Webb<sup>17</sup> employs small irrigations at first for the purpose of establishing habitual morning evacuations. The individual who is fortunate enough to have this automatic function is to be encouraged provided that he is able to remain perfectly clean for a full day between movements. The method of starting this movement varies with the individual. Some find that the thought of a movement is sufficient to initiate it; others find that a glass of cold water or hot coffee, or a cigarette may cause the bowel to function. In our experience very few patients are able to remain perfectly clean for twenty-four hours without irrigations.

#### 4. USE OF APPLIANCES AND DRESSINGS

Colostomy bags are but rarely prescribed. They are never employed for left sided colostomies but are used exclusively in the unusual permanent cecostomy or transverse colostomy when these cannot be controlled by the ordinary methods, because of the liquid stool present in the right side of the colon. The colostomy bag is an unsatisfactory appliance, which is difficult to clean and to keep clean. It distorts the patient's figure. It is usually made partly of rubber and after a week or two of use produces a musty, offensive

odor. It usually is expensive and requires frequent renewal. Irritation of the skin and stoma is a common finding among those who persist in using these bags.

Binkley, Gabriel and Lloyd-Davies,<sup>18</sup> Best, Landsman,<sup>19</sup> and others call attention to the frequent abdominal wall weaknesses and ventral herniae seen about the stoma among those who are addicted to colostomy bags. These are probably caused by ischemia from the pressure of the rim of the bag, or by the suction effect of the bag. The protrusion of bowel all too frequently seen in these cases is due to the suction effect and presumably the more frequent movements are likewise attributable to the same cause. There is no doubt that prolapse and ventral hernia occur among those who do not wear colostomy bags, but the incidence is very much less. Furthermore, we have seen patients develop both hernia and prolapse months after discharge from the hospital after they were fitted with a colostomy bag by their physicians. Prior to this they had repeatedly been examined in the follow-up clinic and found to have neither hernia nor prolapse. It is also true that a low grade inflammation of the exteriorized mucous membrane is often seen in patients wearing colostomy bags. The thick mucus that is discharged constantly from these colostomies is very distressing and quite frequently produces a dermatitis of the surrounding skin. One needs only to watch the offensive, messy spectacle of a patient changing and cleaning the bag in order to be thoroughly disgusted with it. A colostomy bag should be used as a last resort when all else fails, and should almost never be needed for the proper control of a left-sided colostomy.

For the few unfortunates who require a colostomy bag, it is advisable to secure one possessing several important qualities. It should be, if possible, inexpensive, so that a new one may be frequently obtained. The cup fitting over the stoma should have a small diameter so as to lessen the tendency to produce herniae. The straps should be detachable and washable and the contrivance should be relatively flat in order



that it may not cause too great a bulge and distortion of the patient's normal contour.

Patients often find that gauze or cellulocotton, inserted into the colostomy bag at each cleaning, tends to absorb the fluid, and so make the wearer more comfortable, the need for change less frequent, and the cleaning of the bag easier.

It is a mistake to send the patient to a surgical supply house and allow the patient to be fitted according to the whims of the salesman or the stock of the organization. Whenever possible, the physician himself should select the bag.

Ordinarily no appliance is needed and the simplest dressing is employed. After the temporary dressing previously described is removed, it is replaced by the permanent dressing. The exposed bowel is covered with a strip of gauze on which boric acid ointment or vaseline has been applied. Another piece of gauze is placed over this and a pad of cotton or cellucotton is then applied. Some patients have strips of adhesive on either side of the abdomen; to these strips are tied pieces of tape, and these are tied across the dressing. The majority of patients merely wear their supporting belts over the dressing with a piece of oiled silk interposed between the belt and the dressing. Most patients wear a belt and all are encouraged to do so. A simple belt made of elastic webbing is quite satisfactory, inexpensive, and may be made by the patient. They have some tendency to roll at the sides and are at times productive of postprandial pressure and discomfort. An adjustable abdominal support made of knitted elastic, narrow over the sides and back, and broad in front, with two or three pliable vertical supports anteriorly, has been found most satisfactory. Some patients have in addition a simple elastic belt or muslin binder which is used at night.

#### 5. CARE OF THE SKIN

It is surprising to find how well the skin about an artificial anus will appear, if the anus is cared for in the manner described. Occasionally, however, especially in cases

in which a colostomy has been made in the right half of the colon, a certain amount of chronic and acute dermatitis may occur.

In the prevention and treatment of dermatitis, any ointment which adequately protects the skin from the irritant to which it has been subjected may be used. The ointment we have found to be most efficacious is made of 10 per cent zinc oxide and 10 per cent finely powdered aluminum in anhydrous lanolin. This is applied on the thoroughly cleaned and dried skin all about the stoma, and the usual dressings applied. It is of great importance that the patient keep watching for the first sign of dermatitis because when it is moderately advanced, it is quite difficult to cure. An ointment should be used constantly if the stoma discharges irritating stool, liquid stool or much mucus.

Occasionally excessive granulations form at the junction between the skin and the mucous membrane. These not infrequently bleed slightly, causing blood spots on the dressings which are viewed by the patient with great consternation. One or two applications of strong silver nitrate to this area will result in prompt disappearance of the granulations and in the cessation of the bleeding. Rarely, the rough introduction of the irrigation tube has caused bleeding, but no cases of perforation or any serious consequences have come to our attention.

Stenosis of the opening of the artificial anus is not harmful provided that sufficient opening exists so that stool can easily emerge. Moderate stenosis is successfully treated by simple dilatation with the finger or with bougies, preferably after the infiltration of novocain in the surrounding skin. If, however, the stenosis is accompanied by progressive retraction of the exposed bowel into the abdomen, corrective surgical procedures are indicated.

#### 6. GENERAL MEASURES

All patients are given instructions in the proper methods of self irrigation and colostomy care before they are discharged from the hospital. This includes the performance by the patient of all manipula-

tions under guidance. They are also given printed directions for the proper method of open irrigation, a list of foods to be eaten, a list of foods to be avoided, and a typical diet. Those who may require it are visited at home by a nurse who further instructs the patient and some member of the family in the proper methods of colostomy care, and elucidates any points not completely understood by the patient.

Initially, the patients are seen by the physician at frequent intervals, and alterations in the régime, including dietary additions, are prescribed if indicated. Subsequently, after adequate regulation is attained and the greatest dietary freedom commensurate with marked constipation realized, the patients are seen only at intervals of four to six months. The weight is observed, and a search is made for distant metastases. The colostomy is carefully examined for local recurrence, stenosis, retraction of the spur, prolapse and hernia. With a finger deep in the colostomy, local recurrences, glands involved by metastases, or peritoneal implants may be palpated long before their presence will be discernible in any other fashion.

Most patients learn by trial and error just how much exercise they may safely do. Very unusually patients report small movements after moderately severe exertion; the obvious treatment is curtailment of the more violent types of exercise. As a general rule, however, very little stress need be placed on restriction of activity.

Individualization is a *sine qua non* in the management of a colostomy. It is only to be expected that great variation will be found in the response of patients to the initiation and continuation of life with a colostomy. Whereas most patients will accept the colostomy with fortitude, if not stoically, and will coöperate with willingness, others may threaten suicide, refuse any form of self care, and require trained attendants for months after operation. It is obvious that methods employed successfully with the first type of patient will be insufficient with the second type of patient. The latter will require frequent long talks

to break down the resistance to self care and to promote acceptance of colostomy life. Finer variations in response are treated according to the best judgment of the physician and his knowledge of their psychology. Each patient must be considered as an individual and as an individual problem, and the routine varied accordingly. Infinite tact, patience, and finesse are required in caring for these patients to whom the colostomy comes as a loathsome disfigurement and as an unnatural, hideous deformity. Yet it is possible, by proper schooling and guidance of thought and action, to restore these people to such an excellent state of almost normal existence that the attending physician himself may be amazed, and most certainly, pleased.

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# DIVERTICULOSIS OF THE COLON

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**D**IVERTICULA are noted at all points in the intestinal tract from the pharyngo-esophageal junction to and including the rectum. While accurate anatomic descriptions, chiefly from post-mortem studies, were given by various authors—notably Virchow, Graser, and Fischer—during the latter part of the last century, the appreciation of their surgical significance came with the beginning of the present century, the attention of the profession being directed by the papers of Beer, W. J. Mayo, Moynihan, Drummond, Lockhart-Mummery, and others.

In the last twenty-five years the literature upon the subject has become quite voluminous, based upon clinical and pathologic studies of a sufficiently large number of cases to warrant accurate interpretation of pathology, diagnosis, and treatment. The fact that in their symptomatology diverticula offer a counterpart of other diseases common to the intestinal tract at the points at which they occur lends an added interest to their study. They occur as sacculations projecting from varying portions of the circumference of the intestinal tube—mesenteric, antemesenteric and lateral—and range in number from one to several hundred. Hausman reported one instance in which 400 were found. While occurring in all portions of the intestinal tract, they reach their greatest profusion in the colon, particularly in its left half. Diverticula have been described as congenital or true, and acquired or false, the former containing all the coats of the intestinal tube, the latter representing protrusions or herniations of the mucous and submucous coats through apertures in the muscularis. The term diverticulosis connotes the presence of such sacculations

while diverticulitis implies the varying changes which occur as the result of irritation and inflammation.

Autopsy records would indicate their occurrence in 5 per cent of all subjects over 40 years of age. While the vast majority are seen at and after middle life, they have been reported at much earlier ages, A. P. C. Ashhurst reporting a sigmoid diverticulitis in a child of 7 years and 9 months and Erdmann one in a child under 7 years of age. Only twenty in 1,819 patients at the Mayo Clinic showing diverticulosis of the colon were under 40 years of age. Diverticula of the sigmoid are by far the most common, the descending colon also being frequently involved. It is estimated that on an average 85 per cent are found in these two portions of the colon. The rectum, transverse and ascending colon share in the distribution of the remaining 15 per cent, with infrequent similar findings in the appendix. Our series shows twelve patients presenting diverticulosis of the appendix, in one of whom a diverticulitis with perforation had occurred.

Stout reports an incidence of 1.89 per cent of diverticulosis of the appendix in the cases of appendicitis operated on at the Presbyterian Hospital, New York, in one year. The diverticula occur between layers of the mesoappendix, projecting from the appendix like buds, and are frequently multiple. In addition to the danger of diverticulitis and perforation, simple diverticula afford an added risk, since in the process of cutting through the mesoappendix close to the appendix they may be opened, with resultant contamination of the operative field. While diverticula of the colon may be single, they are as a rule multiple, varying in number within rather wide limits. Practically all of those ob-

served in the colon are of the false or acquired type, the sac consisting of mucosa and submucosa covered with peritoneum.

The fact that they are of the acquired type and occur late in life has not prevented the assumption by some that the fundamental cause is an inherent weakness of the intestinal musculature which has existed since birth, in other words that they are essentially congenital in origin. Since they are of the pulsion type, it is logical to assume that muscular weakness, whether congenital or acquired, is the fundamental factor and increased intracolonic pressure the exciting cause in their production. It has been argued that they occur as the result of the weakening of the intestinal musculature by the piercing of the muscles by the vessels of the bowel wall: their appearance at points other than these corresponding to the entry and exit of vessels would clearly indicate that other factors play a part.

Regardless of the cause—upon which there is no unanimity of opinion—once the diverticulum is formed it becomes a bottle-shaped process, with a narrow mouth and wide body, into which the fecal current enters with the eventual formation of fecaliths. There is consequent inflammatory change secondary to the obstruction and stagnation. There are no symptoms referable to simple diverticulosis. The number of such patients that ultimately develop diverticulitis and present subjective symptoms is conjectural, but has been estimated at from 10 to 20 per cent. The symptoms are caused by inflammatory changes in the sac and surrounding structures, notably in the mesentery, dependent upon inadequate drainage of the sac. The fecal current in the right half of the colon is largely liquid while that in the left half tends to become more and more solid. As a result diverticula in the left half more frequently show the presence of fecaliths which obstruct drainage and predispose to the development of inflammatory changes. They are always potential and often actual foci of acute or chronic infection and merit

attention not as rarities but as abnormalities which may remain innocuous or give rise to symptoms of varying grades of severity and to pathologic changes which may prove amenable to treatment or end in disaster.

The symptoms necessarily depend upon the character and extent of the changes present. With acute inflammation in a single diverticulum they closely resemble those of appendicitis—pain, nausea, and vomiting, localized tenderness and rigidity, and increased leucocyte count. If the diverticulum happens to be situated in the cecum or ascending colon differential diagnosis will be impossible until the abdomen is opened; and because of the mimicry of appendicitis such cases are almost routinely subjected to operation. When the lesion is in the left half of the colon a preoperative diagnosis can be more readily made.

Granting the presence of a diverticulitis one of several results may follow, namely, resolution; perforation with resultant diffuse peritonitis; abscess; perforation into a surrounding viscus (bladder or intestine); ischiorectal abscess; and thickening of the gut wall, mesocolic, and surrounding fat so that obstruction of varying degrees results.

Opinion is divided as to the wisest course to pursue in the presence of an acute diverticulitis. Most surgeons prefer to pursue an expectant plan of treatment until complications arise which necessitate surgical intervention, i.e., perforation or abscess; while others advocate immediate operation, consisting of excision of the diverticulum with closure of the opening in the intestine or simple drainage as local conditions warrant. Since diverticula are so frequently multiple, the removal of one that presents acute inflammation affords no immunity to the remaining ones against similar changes, and moreover since the acute inflammatory process frequently comes to a spontaneous end it would seem the part of wisdom to treat them expectantly until the advent of complications that demand surgical intervention.

Perforation into the peritoneal cavity produces a diffuse suppurative peritonitis not distinguishable from that produced by other infectious lesions and demands similar treatment. The peridiverticulitis, almost uniformly noted, makes this complication a rare one. Both in free perforations and in those resulting in localized abscess formation attempts at repair of these are successful, while the remainder, like those treated with drainage alone, result in fistulae. The latter are usually of small caliber and frequently heal spontaneously. When they persist, secondary closure or resection can be done later, after subsidence of the acute reaction lessens the hazard.

The subjective symptoms noted in chronic diverticulitis consist of periodical attacks of digestive disturbance with abdominal discomfort and uneasiness and at times definite pain which is usually referred to the site of the infected diverticula. Localized soreness and tenderness can usually be elicited in the region of the diverticulitis and not infrequently a mass can be felt. Roentgenologic study constitutes the most important aid in diagnosis, not only locating the site of the lesion but determining as well the extent of the involvement.

Many of the chronic cases prove self-limiting, presenting occasional periods of more or less activity with long intervals of quiescence. Such instances require no treatment other than supervision of diet with prevention of constipation. The oral administration of one of the petroleum preparations and the rectal use of oil or other soothing enemata will be of help. If spasticity is revealed by the x-ray the addition of belladonna or stramonium to the above regimen will frequently suffice to relieve it.

The complications induced by chronic diverticulitis which demand surgical relief are fistulae and obstruction. The fistulae may communicate with the skin, adjacent intestine or bladder. The diagnosis of the former is self-evident; the entero-intes-

tinal type will usually be revealed only at operation, while the enterovesical variety is evidenced by vesical irritability with the passage of feces and gas per urethram. The latter are easily demonstrated by cystoscopic examination. Operative correction of such fistulae may in some cases prove relatively easy, in others it entails difficult and hazardous procedures. The excision of the tract with closure of the opening in the bowel is the ideal. In our experience, this can, as just stated, be readily done in some instances, in others resection of the thickened, distorted bowel will be required. The enterovesical fistulae, if situated high up on both the bladder and sigmoid, are accessible to manipulation and correction; if, however, the opening is located low down in both organs, the difficulty of access combined with the inflammatory infiltration make its correction both difficult and hazardous. In such cases we have elected to do a permanent colostomy with satisfying results.

Obstruction may occur in acute diverticulitis as a result of infection and edema particularly when there is involvement of an appreciable segment of the sigmoid: the localization of the pain, the acute sensitiveness of the frequently palpable mass, the elevation of temperature and the accompanying leucocytosis will all point to inflammatory rather than neoplastic origin but will not exclude perforating carcinoma which may produce an identical clinical picture. The previous clinical history will in most instances afford a differentiation, while in the occasional case further observation will be required for a distinction between them. When the obstruction is incomplete it not infrequently subsides under expectant treatment, when further study can be safely made. When complete, the obstruction at once assumes a position of urgency; an enterostomy proximal to the lesion is indicated for relief. This procedure often permits resolution of the diverticulitis to such an extent that no further surgery is needed: when such a fortuitous outcome does not obtain, or

should the obstructive lesion prove malignant, subsequent resection can be more safely carried out.

Chronic obstruction is due to hyperplasia, adhesions and angulation, the so called hyperplastic, stenosing type. Especial interest attaches to this type of diverticulitis since it may closely simulate carcinoma or be impossible to differentiate, its successful treatment demanding as much judgment and skill. The symptoms include varying degrees of discomfort, flatulence, pain referred to the lower left abdomen, constipation, obstipation and obstruction. Since the lesion often involves a longer segment of the bowel than does carcinoma, a mass is more likely to be palpable, usually sensitive to the touch. The barium enema shows a lesion which narrows the lumen, often more extensive than carcinoma but at times not distinguishable from it: the presence of one or more diverticula in the neighborhood are suggestive but not pathognomonic since carcinoma is as likely to affect the colon in the 5 per cent of individuals who have diverticulosis as in an equal number of those in whom such is absent. A sawtooth serration of the barium shadow, due to compression of the mucosal folds, is quite characteristic when present. Digital palpation of the rectum has only an exclusion value and the proctoscope shows only thickening and edema.

Resection, where general conditions do not contraindicate its employment, is the treatment of choice. As with colonic resections for other lesions, experience has shown the two-stage operation to be the safer procedure. Drainage of the bowel proximal to the obstruction allows recession of the inflammatory phenomena at the site of the diverticulitis and the upbuilding of the patient's vitality, both of which enhance the safety of the second stage. Both the suture

and Mikulicz type of resection have proved satisfactory, the choice being determined by the experience and preference of the surgeon. The Mikulicz procedure is more applicable here than in carcinoma since the tendency to less radical resections is of smaller moment and there can be no grafting of the disease into the wound. The presence of blood in the stool is noted in a small percentage of patients with the obstructive type of diverticulitis. That it is not more frequently present is due to the fact that the disease is not an ulcerative one, the pathologic changes being largely extramucosal and found in the wall of the bowel, the mesocolic and surrounding fat. Jones quotes Spriggs as stating that bleeding occurred three times in sixty-eight cases of diverticulitis, or 5 per cent, and Rankin as stating that it occurred thirty-three times in 227 cases, or 17 per cent. The presence of blood in the stool which can be demonstrated with the proctoscope to come from above the lower rectum has so great a diagnostic value for carcinoma of the colon as to make the differential diagnosis between carcinoma and diverticulitis at times extremely difficult when this symptom is present. The x-ray may show one or more diverticula and the lesion causing the bleeding still be carcinoma. The history, the duration of symptoms, the character of defect as revealed by the x-ray are all of value in reaching a decision.

A study of the recent literature indicates the incidence of carcinoma developing on diverticulitis at from 1.7 to 8 per cent. This incidence, together with the difficulty in distinguishing between carcinoma and diverticulitis in the presence of a palpable mass or defect revealed by the x-ray, and associated with bleeding from above the lower rectum, makes early exploration a far safer procedure in all such cases than medical regimens which involve delay.

# THE TREATMENT AND PROGNOSIS OF DIVERTICULITIS OF THE COLON

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**D**IVERTICULA may extrude from the wall of any hollow viscus. Some diverticula, such as Meckel's diverticula, which occur in 1 to 2 per cent of all persons, are developmental anomalies, while others, such as traction diverticula of the esophagus, may be associated with an inflammatory process of neighboring structures. In most cases there is no obvious explanation for the presence of the diverticula that are encountered in the gastrointestinal tract or in the urinary bladder. Obviously, increased inward pressure and weakness of a portion of the visceral wall are physical reasons but the "why" is not understood.

At The Mayo Clinic, the incidence of diverticula of the colon is 6 per cent in cases in which the patients are observed clinically and 5 per cent in cases in which necropsy is performed. Spriggs and Marxer found diverticula of the colon in 10 per cent of 1,000 consecutive cases in which roentgenologic examination of the gastrointestinal tract was performed. This is probably a maximal figure. In contrast, Kocour said that diverticula were found in 127, or 1.9 per cent, of 7,000 consecutive cases in which necropsy was performed.

The age, and to a lesser extent, the sex of patients who have diverticula of the colon have always been of interest. Aside from a few rare instances of apparently true congenital diverticula of the colon, the condition is uncommon under the age of 40 years and rare under the age of 30 years. I do not know if race is a factor; relatively few negroes and even fewer Asiatics are examined at the clinic. In this particular study, only one negro, who was a female, was encountered.

Table I shows the age and sex of the patients in 596 of approximately 1,100 cases of diverticulosis and diverticulitis which were observed at the clinic in the decade January 1, 1919 to December 31, 1928, inclusive. The ratio of men to women in the 596 cases was 1.6:1. In all cases observed at the clinic the ratio of males to females is 1.04:1. In ninety-nine of the 596 cases operation was performed for diverticulitis. Table II shows the age and sex of

TABLE I  
AGE AND SEX OF PATIENTS IN 596 CASES OF  
DIVERTICULOSIS AND DIVERTICULITIS  
OF THE COLON

Sex*	Age					
	20 to 29	30 to 39	40 to 49	50 to 59	60 to 69	70 to 84
Men (367, or 61 per cent).....	..	18	63	146	109	31
Women (229, or 39 per cent)...	1	8	41	100	69	10
Total (596 cases).....	1	26	104	246	178	41

\* The ratio of men to women was 1.6:1.

TABLE II  
AGE AND SEX OF PATIENTS OPERATED ON FOR  
DIVERTICULITIS OF THE COLON (1919-1938  
INCLUSIVE)

Sex	Age					
	20 to 29	30 to 39	40 to 49	50 to 59	60 to 69	70 to 80
Men (122, or 63 per cent).....	1	7	34	43	33	4
Women (69, or 37 per cent)...	..	2	19	24	22	2
Total (191).....	1	9	53	67	55	6

the patients in 191 cases of diverticulitis in which operation was performed in the two decades January 1, 1919 to December 1938,

Spriggs and Marxer described what they believed was a prediverticular stage. Lockhart-Mummery reported that the

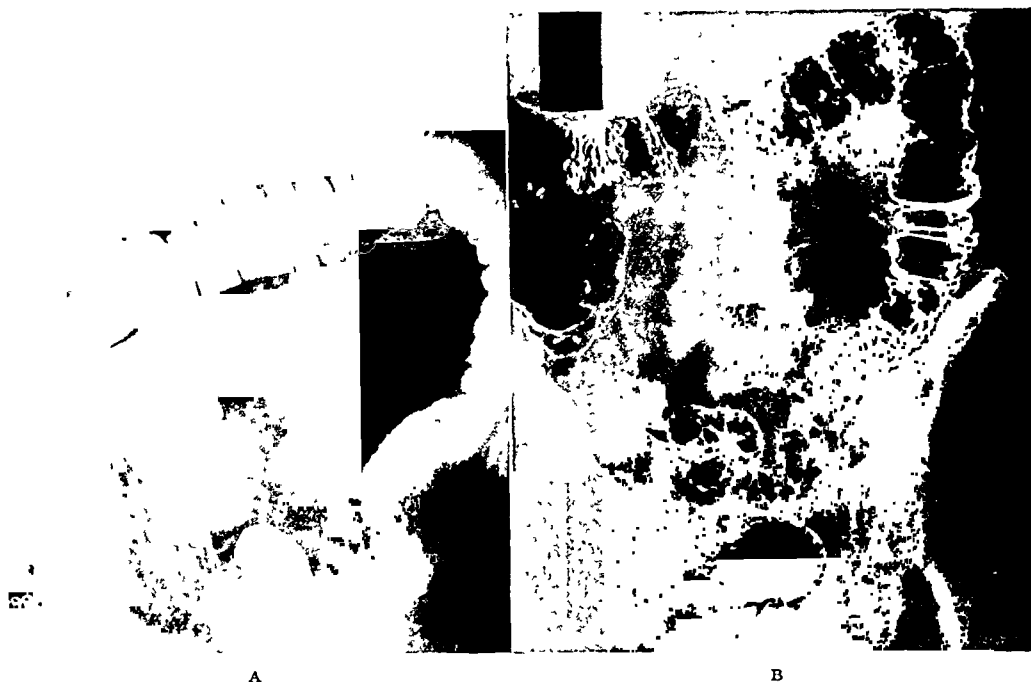


FIG. 1. A, diverticula of colon and diverticulitis of the sigmoid as demonstrated with the usual technique. B, air technique visualizes much more clearly the numerous diverticula as well as the diverticulitis in the sigmoid.

inclusive. Ninety-nine of the 191 cases also are included in Table I. In the 191 cases in Table II, the ratio of men to women was 1.8:1.

According to Dixon, Deuterman, and Weber, the site of diverticula of the intestine is as follows: duodenum in 18 per cent, jejunum in 6 per cent, ileum in 1.5 per cent, cecum and ascending colon in 4.5 per cent, transverse colon in 3 per cent, descending colon in 4.5 per cent, sigmoid in 59.5 per cent and rectum in 3 per cent of cases, respectively. If one considers only diverticula of the colon, the sigmoid is involved in 75 to 80 per cent of cases. The involvement may be limited to the sigmoid or diverticula may be present in other segments of the colon. Diverticula of the colon and an area of diverticulitis of the sigmoid are nicely demonstrated in Figure 1. Especially striking is the depiction of the diverticula after evacuation of the barium and inflation with air.

diverticula increased in number and size in cases in which the patients were observed for years.

I continue to be perplexed by the fact that diverticulitis develops in only a small proportion of patients who have diverticula of the colon. As Marckley and I noted, diverticulitis was present in 376 of more than 1,100 cases of diverticulosis. This suggests that diverticulitis apparently occurs in a third of the cases of diverticulosis but this is true only for this group of cases. A careful record is not made of all diverticula that are found on roentgenologic examination nor do all patients who are 40 or more years of age undergo this examination. It is probable that many people who are 40 or more years of age have minor attacks of abdominal pain which are never sufficient to warrant medical care but which may be due to mild diverticulitis. However, the number who experience sufficient trouble to seek medical advice is



not likely to be more than 10 per cent of the total number who have these peculiar little pouches in the colon.



FIG 2. Diverticulitis of sigmoid with extravasation of opaque material from perforation. Abscess of psoas muscle developed later by extension of the infection.

Likewise there is another puzzling question: why do complications which require surgical treatment develop in some cases of diverticulitis but not in others? This question is as unanswerable as it is in cases of duodenal ulcer. The ratio of patients who require surgical or medical treatment for diverticulitis is purely dependent on the cases studied; therefore, one cannot predict that a certain percentage of patients with diverticulitis will eventually require surgical treatment. This would seem to be proved by my previous report which showed that of 277 patients who had diverticulitis, only four are known to have undergone operation after they left the clinic.

The first report of the surgical treatment of diverticulitis was made by Mayo, Wilson and Giffin, in 1907. Their teaching has done much to establish our knowledge of the surgical treatment of this disease. In many cases the disease is acute from the onset

and operation has to be undertaken without delay. It is interesting to note the duration of symptoms in the ninety-two cases in



FIG 3. Complete obstruction of colon at junction of sigmoid and descending colon, successful resection of involved segment.

which operation was performed in the decade 1929 to 1938 inclusive. In this decade the diagnostic acumen should have improved and all possible measures were undertaken in an effort to avoid operation. In seventeen of the ninety-two cases symptoms had been present for one month or less when operation was performed. In thirty-seven cases symptoms had been present for one month to one year before operation was performed at the clinic. In six of the thirty-seven cases an operation had been performed before the patients came to the clinic. The operations that had been performed in these cases were as follows: drainage of an abscess, colostomy and exploratory laparotomy. A diagnosis of carcinoma had been made in some of these cases. Medical treatment had proved unsuccessful in at least eight of the fifty-four cases in which symptoms had been present for a year or less before operation and there is no doubt that medical treatment had been employed in other cases in this group. It is especially interesting to note that in these fifty-four cases the

progress of the disease was so rapid that operation could not be delayed.

Medical treatment was especially disappointing in the twenty-seven cases in which symptoms had been present for one to five years before operation was performed at the clinic. In nine of the twenty-seven cases, operation had been performed before

plication of prior medical failure still holds. There is no question that there has been, and should be, a determined effort to avoid operation but it is futile and even dangerous to continue medical treatment after complications have developed. I have the same impression that I expressed previously, namely, that in some cases of

TABLE III  
RESULTS OBTAINED WITH VARIOUS SURGICAL PROCEDURES IN 191 CASES OF DIVERTICULITIS OF THE COLON

Surgical Procedures	Results						
	Cases	Alive and Well	Died after Operation	Died of Related Condition	Died of Unrelated Condition	Not Well	No Data
Preliminary colostomy; subsequent resection of colon and closure of colonic stoma	27	14	7	1	1	3	1
One-stage resection of colon	8	5*	1		1	1*	
Obstructive type of resection of colon and subsequent closure of colonic stoma	20	11*	4		1		4
Colostomy only	36	9	3	5	8	9	2
Mikulicz type of resection of colon	31	19†	3	3	5	1	
Colostomy and subsequent closure of colonic stoma	22	10		1	3	8	
Closure of perforation	10	3		2	4	1	
Drainage of abscess	12	5			2	4	1
Emergency cecostomy	6	3	2		1		
Exploratory laparotomy	13	4	1		1	5	2
Miscellaneous procedures	6	1	1	1		2	1
Total	191	84 (43.9%)	22 (11.5%)	13 (6.8%)	27 (14.1%)	34 (17.8%)	11 (5.7%)

\* Colostomy in one case.

† Four patients have a sinus.

the patients came to the clinic and thorough medical treatment had been employed in at least four of the nine cases. In four of the ninety-two cases symptoms had been present for six to ten years and in seven cases symptoms had been present for more than ten years before operation was performed. Therefore, in thirty-eight cases the patients had had symptoms from one to more than ten years. This is an indication of the failure of medical treatment. Although ten of the thirty-eight patients had undergone some type of operation which had failed to cure the condition, the im-

diverticulitis the symptoms are severe almost from the onset and operation eventually will be required.

The most serious complications are perforation with abscess formation (Fig. 2) around the bowel, and extensive tumefaction with obstruction (Fig. 3) and perforation of the disease process into an adherent loop of bowel, into the bladder or through the abdominal wall. Occasionally one encounters a patient who is seriously ill, with high fever, leucocytosis and an abdominal or pelvic mass, and operation seems inevitable. Finally there is a sudden dis-

charge of pus from the rectum as the abscess fortunately ruptures and drains into the bowel. Recovery may ensue without operation. When a patient passes cloudy urine and gas is expelled from the urethra at the end of micturition, one can be practically certain that the patient has a vesicosigmoidal fistula, and the most common cause of spontaneous vesicosigmoidal fistula is diverticulitis of the sigmoid. In a few cases, fecaluria has occurred so insidiously that operation has been performed for a vesical condition and the true cause has been established only at the time of operation.

Another source of diagnostic error occurs more often among women than among men. There may be vague, indefinite symptoms of lower abdominal and pelvic distress and a mass may be felt on bimanual examination. Because of the mass, operation is undertaken and sigmoidal diverticulitis is encountered. Roentgenologic examination of the colon in the hands of an expert rarely leads to error but such examination occasionally discloses a filling defect that is not readily distinguishable from the defect caused by cancer. Very properly the surgeon cannot delay operation if cancer is suspected.

The immediate and late results of some of the surgical procedures are listed in Table III. Resection of the diseased segment, if possible, is the most radical but the most certain method of effecting a cure. Colostomy alone is required in some cases, usually in those cases in which a large mass and often in cases in which a fistula remains at the site of the drainage of an abscess. This is a lifesaving but not a curative procedure; however, patients can and do remain in fair health without any further operation. Colostomy, followed in some months by closure of the colonic stoma, is not a very satisfactory operation. However, if a vesicosigmoidal fistula is not present there is about an equal chance that no further operation will be needed. In twenty-two cases a colostomy was performed and the colonic stoma was closed

later. In thirteen of the twenty-two cases the patients were apparently well or died of unrelated causes, but in nine cases the disease persisted.

TABLE IV  
RESULTS OF SURGICAL TREATMENT IN 191 CASES  
OF DIVERTICULITIS

Results	Years since Operation				
	0 to 5	5 to 10	10 to 15	15 to 20	Total
Patients cured.....	34	25	21	4	84
Symptoms persist.....	21	6	6	1	34
Related deaths.....	33	2	..	..	35
Deaths from unrelated or un- known causes.....	16	7	4	..	27
No data.....	..	..	..	..	11

Table iv shows the results of surgical treatment. Many factors enter into the evaluation of results but the chief one is the fact that many patients are in the sixth and seventh decades of life. If the eighty-four cases in which the patients were living and well at the time the data were obtained and the twenty-seven cases in which the patients died of unknown or unrelated causes are included, it will be found that in 101, or 56 per cent, of the 180 cases in which follow-up data were obtained the patients were benefited by the operation. Even in many of the thirty-four cases in which symptoms persist, the patients are not invalids and would have died had they not been treated surgically. That sixty-one patients lived at least five or more years after the operation indicates that all is not sorrow and tribulation in dealing with this serious disease. One may seem optimistic in saying that a patient who has a persistent fecal fistula or a colonic stoma is well but the patients themselves do not consider either of these a serious handicap; they are glad to be alive and to be able to carry on their usual duties.

In cases in which the onset of the disease is acute, the treatment is most difficult as

one has to decide whether operation should be performed at once. Fortunately such cases are few. Probably the next most serious type of diverticulitis is that associated with a vesicosigmoidal fistula. A hole between the colon and bladder is a serious condition because ultimate infection of the entire urinary tract is almost certain to occur. Probably one of the earliest descriptions of this complication was that by Freund, in 1730. Gouverneur, Soupault and Latifi found such fistulas in thirty-eight, or 11 per cent, of 324 cases of diverticulitis of the sigmoid. Higgins reported 328 cases of vesicosigmoidal fistula and found that in 160 of the cases the fistula was the result of an inflammatory condition; in ninety-two of the 160 cases the patients had diverticulitis. Lockhart-Mummery encountered a fistula in twelve of ninety-one cases of diverticulitis in which he operated.

A vesicosigmoidal fistula was present in thirty, or 15 per cent, of the 191 cases in this series. There were seven postoperative deaths and later in the succeeding months four more patients died of a continuation of the infection. Nineteen patients survived the operation for months to years; twelve of the nineteen were apparently well but seven had more or less persistence of the disease.

In twelve of the cases of vesicosigmoidal fistula in which the patients were cured, a resection of the diseased segment of the colon was performed; in four cases, remarkable to learn, the fistulous tract was simply closed; and in one case a colostomy resulted in closure of the fistula but the colonic stoma has remained open.

It is unusual to encounter fistulas of the bladder complicating diverticulitis in cases in which the patients are females. The anatomy of the female pelvis naturally explains this, but in three of the thirty cases in which this complication occurred the patients were women.

There is an important economic factor in cases in which operation is required. Not infrequently the better part of a year is spent in the hospital, especially in the cases in

which multiple operative stages are required. The patient may be in the hospital from fifty to more than 100 days and intervals of weeks and even months may elapse between the various stages of the operative procedure. Although it does seem that complications will develop in some cases in spite of medical treatment, the long period required for the operative treatment, the 18 per cent mortality (immediate and later) and the 18 per cent of patients who continue to have trouble should spur one to do everything possible to control diverticulitis by medical means.

What medical measures are of value? As with inflammation elsewhere in the body, rest and heat are the chief weapons. The patient who has an acute attack of diverticulitis should be kept in bed, and really kept there, for two to three weeks. It is a frequent error to allow the patient to be up before the process has subsided. The temperature and the leucocyte count may be normal and the patient assures the physician that he "feels fine." That is good news, but tenderness remains over the region involved and roentgenologic study will show persistence of spasm and irritability. Until the inflammation has fully subsided, the patient should be kept in bed.

One of the best methods of directing heat to the involved region is by means of short wave diathermy. Application of heat for thirty to forty minutes, twice daily, to the involved region often serves to effect rapid resolution of a tumefaction. Application of heat by means of the Elliott method is very helpful, especially if the patient is a woman. The rectal attachment may be used if the patient is a man but this often is not well tolerated. Simple electric pads or hot water bottles afford some heat but the penetration and resultant vasodilatation are less pronounced than they are when diathermy is used. Hot rectal irrigations of physiologic saline solution administered by means of two way irrigating tubes, and the use of hot douches are other methods of obtaining heat. Abdominal stupes, if kept hot and if they are not too heavy, likewise afford

some relief; their usefulness is somewhat increased from the angle of "doing something"; it is not psychotherapy but partly so.

What about diet? At the onset of an acute attack, the less taken by mouth, the more the bowel can rest. Ordinarily, water, fruit juices and tea or coffee are permissible but if much obstruction is present, parenterally administered fluids for one or two days may be of great value. As the acute phase subsides, nonresidue foods, such as eggs, rice, arrowroot cookies, butter, broth and gelatine puddings, should be added. Gradually, a normal menu should be resumed. By normal is meant avoidance of foreign and undigestible material. Reports from many patients have stated that "if I avoid nuts, popcorn, bran and berries with big seeds, I have little or no trouble." In only rare instances has it been found necessary for the patient to eat only purées of vegetables and strained fruits. A few patients have found that they are better if they limit the amount of raw fruits and vegetables in their diet, although this is true of many people who have a sensitive intestine but no demonstrable disease of the bowel.

What drugs, laxatives and enemas are to be prescribed? There are no drugs of any curative value, as far as one can judge by clinical observation. Administration of tincture of belladonna, even to the point of physiologic tolerance, is of doubtful value. From time to time new preparations are offered that are said to be "real antispasmodics," but the clinical results have not been encouraging.

Laxatives are sometimes needed, especially in cases in which the patients are elderly individuals who have had more or less constipation for years. In the large majority of cases the administration of 4 to 16 c.c. of liquid petrolatum once or twice daily is all that is needed. A frequently repeated comment by the patient is: "By avoiding the coarse, undigestible foods and taking a daily swallow of the oil, I get along easily." Although some patients

object to liquid petrolatum because of its tendency to leak through the anal sphincter, I urge them to take a "small swallow" once a day. I have no proof that it minimizes accumulation of detritus in the diverticula but advise its use because it causes many patients to feel better. At present there is some objection to the use of liquid petrolatum. The proctologists hold that it seems to delay healing following anorectal operations and that it interferes with the dilatation of the anal sphincter by the normally formed stool. This objection would not apply to patients with diverticulitis. Another criticism is that the oil prevents absorption of vitamin A; if the oil is taken only on arising or on retiring, this possibility is minimized. In the patients who are thin the age old remedy, olive oil, administered orally in daily doses of 30 to 60 c.c., may be all that is needed to obtain a daily bowel movement. Obesity and intolerance prevent its use in the majority of cases.

If more than oil is needed to obtain a daily bowel movement, I suggest 10 to 40 minims (0.6 to 2.6 c.c.) of fluidextract of cascara in water after each meal. There is no serious objection to any laxative but one should stress the wisdom of using as little as is necessary. Nor is there any great objection to an occasional warm enema although it is not wise to take one every day. Enemas should be used only when the bowels have not been moving very well and if there is a sense of uneasiness in the abdomen.

If there are "signs and rumblings" of an attack, the patient should be urged to limit his activities, eat only the lighter types of food, and perhaps spend a day or so in bed, apply heat to the abdominal wall and use hot rectal irrigations.

That this regimen is efficient is borne out by a former report which showed that 63 per cent of the patients treated medically were well and that approximately three-fourths of the remaining 37 per cent were able to carry on with relatively little difficulty.

This same general program, simple as it is, is applied in either the group of cases in which obstructive symptoms predominate or in those cases in which the inflammatory symptoms (one-third) are outstanding. It is important to recall that in most of the cases in which a vesicosigmoidal fistula develops the symptoms are chiefly the result of inflammation; hence, the need for all possible care even though the more dramatic symptoms of obstruction are not present.

This encouraging aspect of the medical management naturally raises a doubt in the surgeon's mind as he points out that medical treatment has failed in most of his cases. He properly comments on the patients who have progressively severe symptoms for one or many years, until the complications compel them to seek his aid. The surgeon sees the worst side of diverticulitis and the cases of severe diverticulitis which he observes in a year make a profound impression on him.

To pass to the other extreme, is it not peculiar that when diverticula are accidentally discovered in the course of an examination, only rarely do any of them cause trouble? Is there any need to prescribe treatment in cases in which diverticulosis is discovered? Is it well not to tell the patient about the pouches for fear that he will ascribe symptoms of them? Since diverticulosis is not a disease but merely a peculiar condition, no treatment per se is indicated. Yet we know that some patients do have severe diverticulitis and hence it is sensible to minimize the chance of serious trouble and advise patients in whom diverticula are found to avoid nuts, bran, coarse seeds, and to take a daily dose of liquid petrolatum.

It is usually advisable to tell the patient that the pouches have been discovered but that they are unrelated to his present complaints, and to explain briefly to the patient what they are and what occasionally ensues, and to advise him to follow the dietary suggestions which have been given. This will forestall a possible incorrect

implication of trouble owing to diverticulosis if discovered by some unscrupulous person and will protect the conscientious physician from "losing face" in the opinion of his patient.

### CONCLUSIONS

1. Diverticulosis of the colon is present in about 5 per cent of people who are 40 or more years of age.
2. It is not possible to predict the number of cases of diverticulosis in which diverticulitis will sooner or later develop.
3. Likewise unpredictable is the number of cases of diverticulitis in which operation eventually will be required.
4. In approximately a sixth of cases in which operation is required, symptoms develop rapidly and operation must be performed within a month or less after the first sign of the disease. In fully half of the cases in which surgical treatment is employed operation has to be performed within the first year of the disease. In the remaining cases the patients carry along from bad to worse for one to several years before operation is undertaken.
5. A vesicosigmoidal fistula had developed in thirty, or 15 per cent, of 191 cases of diverticulitis in which surgical treatment was employed. Three of the patients were women.
6. In 56 per cent of the 191 cases the patients were well; not all of them were perfectly normal but they were well able to carry on a satisfactory life.
7. Diverticulosis is a relatively innocuous condition; in cases of diverticulitis in which the disease can be cared for with medical treatment the outlook is favorable while in cases in which surgical treatment is required the condition is serious.

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ADHERENCE to the principle of non-closure of anal wounds, together with the existence of an apparent immunity of the area to serious infection, are the two important factors which safeguard surgery of the anus and rectum.

# MALIGNANT DISEASE OF THE COLON\*

## FACTORS INFLUENCING THE OPERABILITY, MORBIDITY AND MORTALITY

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THROUGH a gradual improvement in diagnostic methods, physiologic principles, anesthesia and surgical technique, there has come about a marked increase in the number of cured patients who have sought relief from carcinoma of the bowel. Educational programs have been helpful to the physician in calling his attention to early symptoms and signs of the disease. This cancer education has been beneficial to the layman as well, since he is much more apt to have his abdominal discomfort, change in bowel habit, weight loss, fatigability or rectal bleeding thoroughly investigated.

Although many patients still come or are referred with hopelessly advanced lesions, it is fair to say that in many instances the onset of symptoms has been so insidious and without disability that one finds it difficult to place the blame. On the other hand, we see a large percentage of these patients who could have had a cure if they or their physicians had been more alert to the proper interpretation of their earlier warnings. It is encouraging, however, to find the operability and curability of these disorders gradually but surely increasing during the past few years. This is not statistically evident in our group from a percentage standpoint so much as from a marked increase in the number of such patients seeking relief. Not that this means an acute increase in the incidence of the disease so much as that the possibility of cure has been demonstrated.

Many such patients were given no hope of cure by their physicians in earlier years

due to the high mortality and morbidity associated with radical operative procedures. More often the true nature of their ailment remained unrecognized until obstruction or peritonitis from a perforation of the growth made them acutely ill. Now we find an increasing tendency to an earlier diagnosis and with this will come a far greater number of cures.

Progress in the management of malignant disease of the colon has been limited almost entirely to surgery. Radiation, thus far, has proved less effective in this type of cancer than in many other varieties. Development of adequate care has come about in large centers where these cases concentrate. Excellent surgeons in smaller communities meet the situation fairly by referring these less common and more complicated problems to larger hospitals. By improvements in the attack, brought about as the result of experience, many of the less effective methods of handling such lesions have been abandoned.

Extirpation of the segment of bowel containing the growth alone is not sufficient. The lymph node area draining this field must be included in the resection. The patient must be evaluated on the basis of his general condition, the extent and location of his disease, and after careful preparation, operated upon in a logical sequence of events. The ultimate aim is elimination of his cancer and a comfortable existence after his convalescence. It has finally become recognized that a permanent colostomy is compatible with health and happiness. Fortunately, this mental hazard

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is rarely necessary in the treatment of cancer of the colon above the rectosigmoid junction.

The causes of immediate failure in this group of cases are now limited to peritonitis, pneumonia and unpreventable complications, such as coronary occlusion, pulmonary embolus, cerebral hemorrhage, etc. (Table 1.) The first of these may be

TABLE I  
CAUSES OF DEATH IN CARCINOMA OF COLON—RADICAL  
RESECTIONS (1925-1938)

	Cecum	Trans-verse	De-scending	Sig-moid	Total
Peritonitis	10	6	4	21	41
Pneumonia	6	4	1	6	17
Pulmonary embolus	3	2	0	2	7
Intestinal obstruction	1	1	1	2	5
Cardiac failure	0	0	0	3	3
Carcinoma, metastatic	0	0	1	0	1
Pyelitis	0	0	0	2	2
Shock	2	0	0	0	2
Cerebral accident	0	0	0	3	3
Mesenteric thrombosis	0	1	0	0	1
Empyema	1	0	0	0	1
Undetermined	1	1	1	0	3
Total	24	15	8	39	86

reduced to a minimum by carefully staged procedures and aseptic surgery. The incidence of pulmonary complications can be lowered by better preparation and after-care, and by a correct choice of anesthesia and procedure. Deaths may occur from too extensive resections but often one successfully extirpates portions of secondarily involved structures.

The definition of operability is difficult and unless the error is made on the radical side at times many resectable and curable lesions will be left alone or temporized with by proximal drainage or short circuit.

One must realize that cancer of the colon is a remediable disease. The earlier the diagnosis is made, the better the prognosis. The operation must be carefully planned

and undertaken by those sufficiently familiar with the various problems likely to arise. A surgeon loses nothing by acknowledging his limitations. His patients and his confrères respect him more if he bows to greater experience in a situation he meets so rarely that he has been unable to attain competence.

The U. S. Public Health statistics for 1936 state that 15,364 people died that year of cancer of the bowel exclusive of the rectum.<sup>1</sup> This represents about 11 per cent of all the deaths from cancer for that year. Inasmuch as the colon can be safely and adequately resected segmentally or as a whole and since the disease is always curable in its early stage, we should constantly have it in mind. In the years from 1925 to 1938 inclusive, there were 634 patients with cancer of the colon admitted to the Massachusetts General Hospital. Of these, 365, or 58 per cent, were resectable. This operability can be increased only by earlier diagnosis and the abandonment of the idea that some physicians hold that the disease is incurable or that their patient cannot stand the operation. Many patients are denied help until they are obstructed or moribund from perforation or hopeless extension of the disease.

The insidious onset of cancer makes it imperative to take notice of any sign or symptom known to be associated with it. These warnings are often manifested so early in cancer of the colon that it seems reasonable to hope that in the future more of the patients suffering from this disease will appeal for help in a curable state. It is discouraging, however, to find in a yearly analysis of the cases admitted to our clinic over the thirteen year period included in this study that the number of months of delay between first symptoms and admission to the hospital has remained the same; that is, approximately eight months. One could work out on a larger group of cases the influence of delay on curability very accurately. We know from the data we have at hand and from reports accumulated by others that the importance of reducing

the interval between diagnosis and operation cannot be over-emphasized.

In the group considered here, we find a distribution in the colon best illustrated by Figure 1. We have divided the bowel into four arbitrary segments since the procedure of choice may differ considerably in these various locations. In the total 634 cases we found involvement of the cecum and ascending colon in 162 instances or 25.5 per cent, the transverse colon in seventy or 11 per cent, the splenic flexure and descending colon in sixty-one or 9.6 per cent, and the sigmoid in 341 or 53.9 per cent. Thus, those areas where stasis occurs are most often involved and the lower colon is the more likely site.

There were four patients in this group under 30 years of age and six over 80, the youngest being 23 and the oldest 91. The peak is in the fifth decade with 32 per cent. The third decade accounts for 4.6 per cent, the fourth for 18.5 per cent, the sixth 29.5 per cent, the seventh 12.6 per cent and the eighth only 1.1 per cent. Males were 56.5 per cent of the total.

In this same interval of time, 818 patients with carcinoma of the rectum were admitted to the hospital. These will not be considered further in this discussion other than to say that these figures give a distorted view of the comparative frequency of the disease. The 1936 statistics given by the U. S. Public Health Report indicates that carcinoma occurs at least twice as often in the colon as in the rectum. Doubtless fewer surgeons in our community are willing to undertake radical extirpation of the rectum than are ready to operate upon the lesions of the colon.

In considering the various locations of cancer of the colon and the operative procedures giving the most satisfactory outcome, it is only fair to say that each surgeon must adopt the method that gives him the best result. In a careful analysis of our cases operated upon by a number of surgeons, it was obvious that no given set of rules can apply to all men dealing with this problem. One surgeon may have no

mortality from an open anastomosis while another almost invariably will produce a fatal peritonitis. Another may, by his

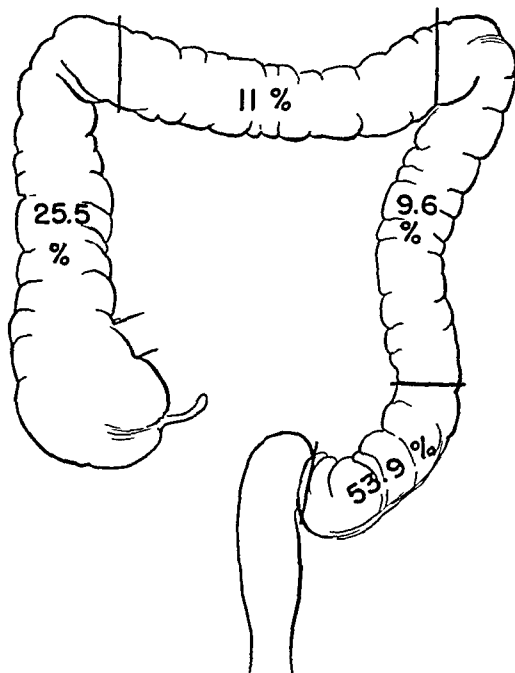


FIG. 1. Carcinoma of the colon. Distribution of cases, Massachusetts General Hospital, 1925-1938.

meticulous technique, have no trouble from local infection but by his prolonged procedure have a high death rate from pneumonia. Aseptic resection in the hands of some men is unsatisfactory due to their inability to adhere strictly to the other important principles of intelligent intestinal surgery. Exteriorization has been used in a small percentage of our cases, usually in the very poor risk patient, and has been attended by a high mortality rate.

It is obvious that one must avoid gross contamination of the peritoneal cavity. The diseased area must be removed and, in most instances, continuity of the bowel reestablished. The blood supply to the anastomosed ends must be preserved. Sutures must approximate the serous coats of the bowel and the mucous membrane must be inverted. There must be no tension on the suture line and no drains resting near it. Traps in the mesentery must be closed and raw surfaces peritonealized

when possible. Proximal complimentary decompression must be established if not provided by a previous procedure. If one

need has passed.<sup>2</sup> (Fig. 2.) In cancer of the right colon, we do a preliminary ileotransverse colostomy. (Fig. 3.) In a few large,

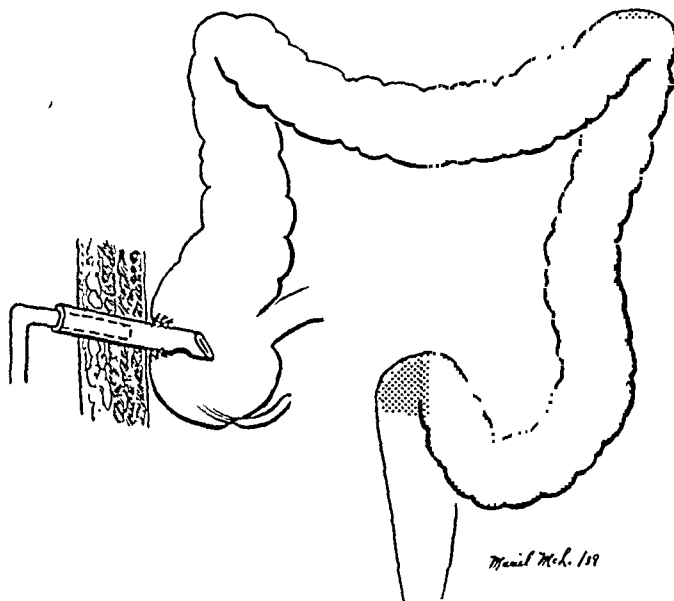


FIG. 2. Preliminary cecostomy. Indicated for tumor located anywhere in the left half of the bowel.

can add to these rules good general surgical principles, the results will be satisfactory.

In our own hands, we have found that two-stage procedures have lowered our

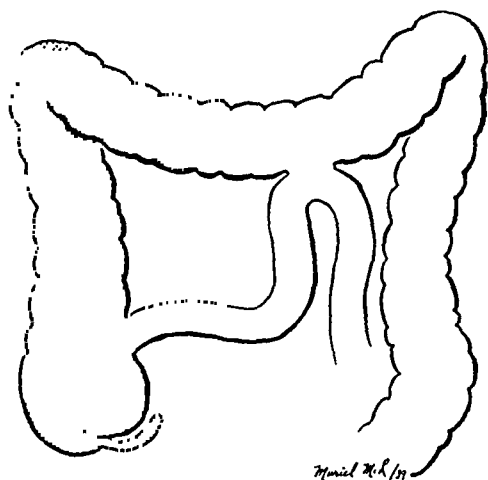


FIG. 3. Preliminary ileotransverse colostomy. Indicated if the tumor is located in the right half of the colon.

mortality. For the left colon, this means a preliminary cecostomy of the type that will function satisfactorily for a period of three weeks and close spontaneously after its

badly infected, obstructive growths, a complete proximal defunctioning colostomy is done as a preliminary operation to resection. (Fig. 4.) The type of temporary colostomy suggested by Devine<sup>3</sup> is a logical procedure; we have carried it out in a few instances and expect to use it more often in the future. We wish to call attention to the feasibility of utilizing the splenic flexure through a subcostal or transverse incision for the Devine colostomy when possible. The permanent scarring with resulting adhesions in the right upper quadrant and mid-abdomen makes it undesirable in many younger individuals who may well need surgery on the stomach or biliary tract in later years.

We believe preliminary proximal operations should be done routinely for malignant lesions of the large bowel whether the patient appears to be obstructed or not, and regardless of the age or condition of the patient. Too many "good risk" patients have succumbed to one-stage operations upon the bowel. We are sure that rarely, if ever, has a well planned two-stage opera-

tion added to the risk of life or interfered with adequate extirpation of the disease. It makes the task a bit harder for the

for the poorer risks. When we consider that the divided operation materially reduces the incidence of the two most prevalent

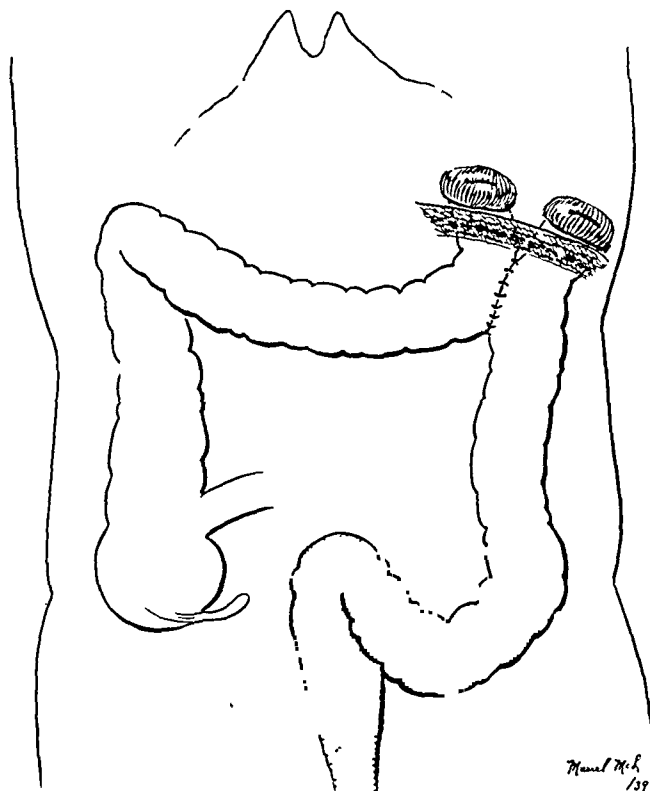


FIG. 4. Modified Devine defunctioning operation. Indicated if lesion is in the sigmoid or rectum, and is large, obstructing, or perforating.

surgeon, and the patient naturally dislikes a second trip to the operating room. Neither of these arguments is sound since both have to do with convenience rather than the chief objective.

We have recorded the facts that the hospital stay of the patient operated upon in two stages for cancer of the colon is increased on an average of ten days but that the fatal complications of peritonitis and pneumonia are materially reduced.<sup>4</sup> In this same report which included carcinoma of the rectum, we found that in 400 one-stage operations there was a mortality rate of 19.2 per cent while in 253 two-stage procedures, the death rate was 13 per cent. These figures were impressive to us since during the years covered by this report, our surgeons were definitely one-stage minded and chose the two-stage procedures

fatal complications in spite of the so-called "double opportunity," there seems little to support the one-stage enthusiast. That creditable results may be obtained by single stage operations in well selected cases by experienced abdominal surgeons we admit, but we are sure that these same men would attain a truly enviable mortality rate if they took advantage of the added safety of the divided attack.

Our personal experience during the period of this study is based on 107 cases of carcinoma of the colon in the regions requiring abdominal approaches only. We were able to extirpate the involved area in all but seven patients, an operability of 93.6 per cent. This high figure means that radical resection was done if the tumor mass could be moved and had not invaded structures necessary to life by direct

extension. By this attitude, the mortality rate was increased but there were many long comfortable respites from recurrence of disease that justified the procedures. Doubtless, our high operability was influenced by the fact that most of these patients were from the private wards, implying, on the whole, an earlier lesion than that found in patients admitted to the general hospital wards. There were ten deaths in thirty-one one-stage operations and five deaths in sixty-nine two-stage procedures. The value of the divided attack is most strikingly illustrated in cancer of the right colon with twenty-two consecutive resections without a fatality.

The next most important factor in the reduction of mortality in this group appears to be the method of handling the sectioned bowel. Since the sigmoid lesions were more prevalent in our series and offer sufficient data for statistical purposes, we will report in some detail the results of various operative procedures in this area. (Table II.) We

TABLE II  
RADICAL RESECTION FOR CARCINOMA OF SIGMOID  
ACCORDING TO TYPE OF ANASTOMOSIS  
(M.G.H. 1925-1938)

	Total	Deaths	Per Cent
Parker-Kerr anastomosis.....	52	6	11
Open anastomosis.....	38	9	23
"Turn-out" operations.....	41	12	29
Mikulicz's exteriorization.....	33	7	21
Anastomosis over—Clamps...	18	4	22
Anastomosis over Combined abdominoperineal.....	10	1	10
Total.....	192	39	20

believe that this gives a reasonably fair representation of the methods used. It must be added that some procedures were more successful in some hands than in others. The extent of the disease, the age and condition of the patient, the degree of obstruction, infection, complicating diseases, etc., played some rôle in the type of operation chosen. Certainly those patients subjected to a modified Mikulicz and the

Jones modification of the "turn out" operation were of the older age group and poorer risks.

It is evident that the Parker-Kerr basting stitch method of suture,<sup>5</sup> as we have modified it in our clinic,<sup>6</sup> has given a lower mortality rate than any of the other methods used. (Fig. 5.) One must be prepared to carry out this technique in great detail or it will fail. The clamps used must be thin and strong. We have modified a long thin clamp with rigid, longitudinally serrated blades.<sup>7</sup> An Ochsner-Kocher tooth at the tip aids in proper alignment and meshing. The basting stitch must be pliable but not easily penetrated. Boilable o chromic catgut on atraumatic needles serves this purpose well. The non-boilable gut is softer and more easily penetrated or held in the tissue by the anastomosing sutures, thus making the withdrawal of the basting stitch more uncertain. The basting stitch must be properly marked, as one end may become tied accidentally to the anastomosing suture. This is easily accomplished if Kelly clamps are routinely placed on one and Ochsner's on the other basting sutures.

One may use a single row of silk mattress sutures as advocated by Halsted, but we have had excellent results with two rows of very fine chromicized catgut. This makes it possible to place the outside posterior row of sutures before the clamps are removed, and thus the ends of the bowel are held together during the remaining steps of the anastomosis. This gives all the advantages of an anastomosis over clamps and eliminates the handicap of the clamp in introducing most of the sutures. A second row of sutures may not be necessary and if one uses interrupted stitches, it probably is best to use only one row. On the other hand, healing takes place from the serous coat of the bowel wall only, and a broader loosely held contact between the two segments seems desirable. This can be accomplished by running sutures locked or tied at the ends to prevent abnormal purse-string action.

The greatest care must be used to leave a small diaphragm at the anastomosis. This requires thin bladed clamps and the suture

It is wise to withdraw the basting stitches after the two posterior rows and the inside anterior row have been placed.

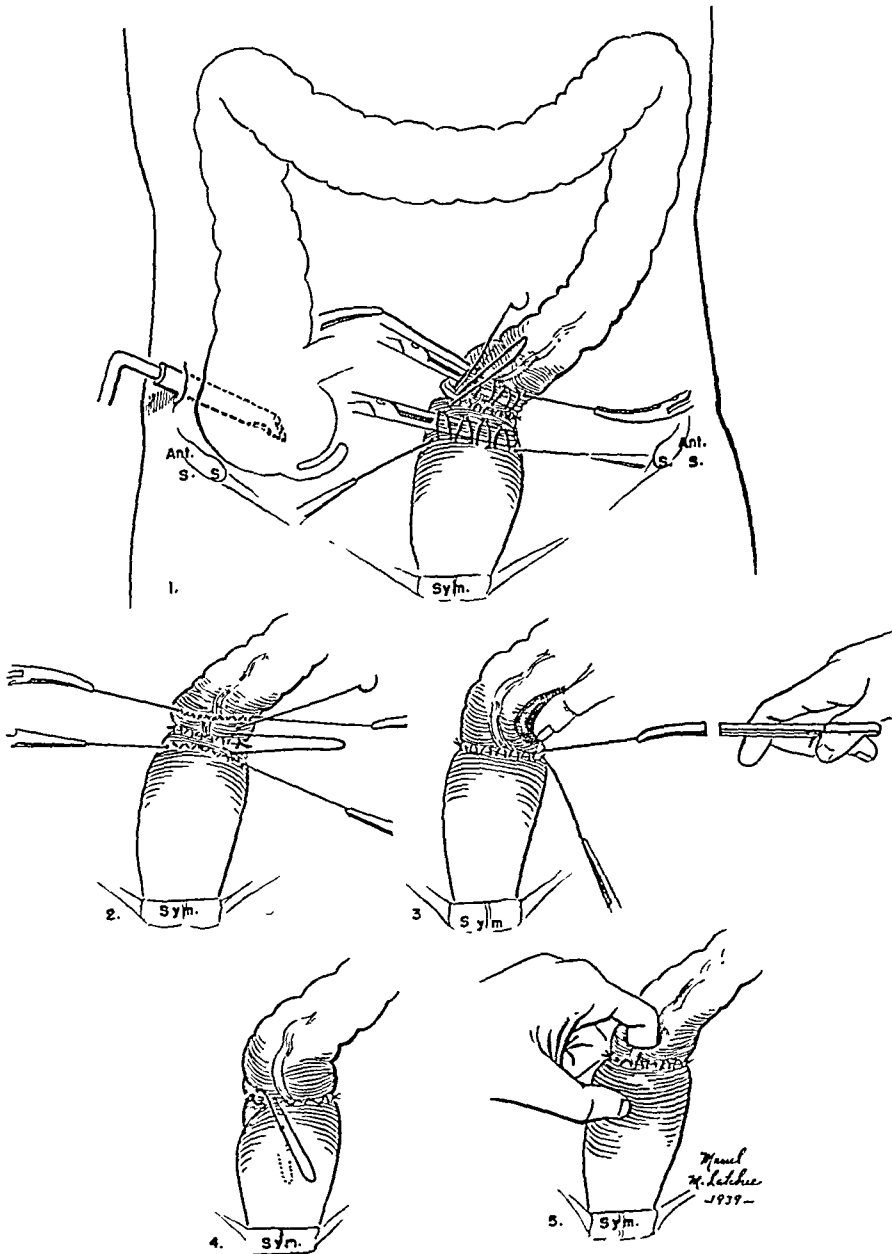


FIG. 5. Modified Parker-Kerr aseptic anastomosis. 1, A preliminary cecostomy has been done at a previous operation. The tumor area has been resected. Basting sutures are in place. The outer posterior row of sutures is being applied. 2, The special clamps have been withdrawn. The inner posterior layer has been started. 3, The two posterior layers and the inner anterior layer have been completed. The basting stitches have been cut and are being withdrawn. 4, The final layer of sutures is being completed. 5, The thumb and forefinger are passed through the anastomosis.

lines placed as near them as is feasible. On the average large bowel, the two lines of sutures which we use would be approximately  $\frac{1}{8}$  to  $\frac{3}{16}$  of an inch apart.

The seared edges of the bowel should be carefully broken up with thumb and finger after the final anterior row of sutures has been made. If the mesentery is thickened

by fat, one may do well to adopt the suggestion of Owings and Stone<sup>8</sup> of applying the clamps in such a manner that the mesenteric border is in the center of the clamp rather than at its edge. Another important detail is not to disturb the fat tabs along the edge of the bowel to be sutured. Many times leakage occurs because the bowel is thus denuded of its blood supply with resulting spontaneous necrosis.

The use of various clamps over which an anastomosis is made, has been successful in the hands of many surgeons. Rankin,<sup>9</sup> Furness,<sup>10</sup> Young,<sup>11</sup> Stone<sup>8</sup> and others have devised instruments for this purpose. These methods have the advantage of eliminating the complicated use of the basting thread with its technical pitfalls. Doubtless with experience and practice, one can use any device that best suits his purpose. One is desirous of approximating the two cut ends of the bowel in a manner that in his hands he can (1) establish satisfactory continuity; (2) produce the minimum of contamination; and (3) obtain a satisfactory end result.

There are thoughtful surgeons who feel that the certainty of an anastomosis under vision is more desirable than attempted asepsis. As our figures show, we have had considerable experience with open anastomosis in our clinic. The results have been good, due to the fact that gross soiling has been avoided. The area is well walled off, the bowel contents kept under control, and as soon as the anastomosis is complete and before the toilet of the peritoneum is begun, all soiled instruments, drapes, and gloves are discarded. This method gives the peritoneum a chance to demonstrate its natural immunity to infection. If the bowel has been well prepared and one does not have to contend with liquid fecal matter, the percentage of successful open anastomoses is large.

At this time, we feel that the possible benefits of peritoneal vaccination should be discussed. We have purposely avoided routine preoperative vaccination other than that possibly obtained by a pre-

liminary proximal drainage or short circuit procedure. It has been our contention that vaccination carried with it some risk in itself and that it very definitely had a tendency to make the surgeon less careful in his technique. We are now convinced that there is a use for vaccination on the basis of the research of Steinberg,<sup>12</sup> as well as that of Collier, Ransom and Rife.<sup>13</sup> We do not advocate preliminary vaccination as a routine but we do feel that any large bowel resection contemplated in one stage should have vaccination beforehand. Inasmuch as we are two-stage advocates, at the present time it is obvious that we have more faith in the divided procedure than we do in vaccination. The term peritoneal immunity is a broad one and since the flora of the intestinal tract varies so widely, it is difficult for us to see how gross contamination can be combated by any method of preliminary vaccination. On the other hand, if contamination takes place accidentally at the time of operation or if early peritonitis is already present, then certainly one is justified in any method that, by careful laboratory studies, indicates a rapid immunity to invading organisms. If one can, without harm to the patient, increase his resistance to spreading peritonitis, one should certainly do so. We warn against placing trust in vaccine rather than careful surgical principles, but use it as an adjunct to good technique, if at all.

If one feels more secure with exteriorization operations, the obstructive resection advocated by Rankin<sup>14</sup> is the most logical. The development of the exteriorization operation is usually credited to Mikulicz.<sup>15</sup> He popularized the procedure originally used by Bloch.<sup>16</sup> Paul's operation,<sup>17</sup> which involved the immediate removal of the exteriorized bowel, preceded that of Mikulicz, and, in view of our present knowledge, is superior. Rankin's operation allows an adequate dissection of the mesentery and the removal of a wide margin of bowel on both sides of the growth. It also makes possible the immediate removal of the diseased structures with the actual cautery between clamps, thus avoiding contamina-

tion of the wound and peritoneal cavity with bowel contents. It also eliminates the possible implantation of cancer cells in

The modification of the "turn-out" operation, as advocated by D. F. Jones, has a definite place in this discussion.

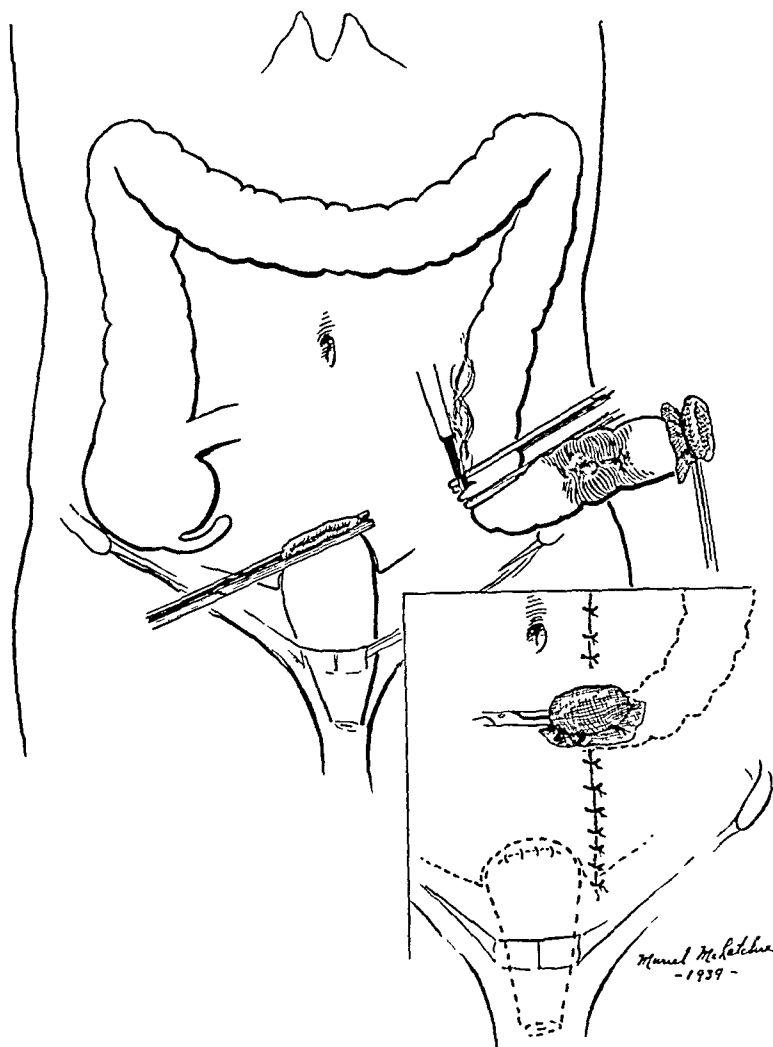


FIG. 6. The "turn-out" operation as practiced by D. F. Jones. The rectal stump is too short for anastomosis. It must not be buried below the pelvic floor.

the wound, which so often took place by the original Bloch-Mikulicz operation. We acknowledge the safety of this procedure from the standpoint of mortality and cure. Our objection to it is the long disability due to the difficulty in obtaining a satisfactory or spontaneous reestablishment of the fecal stream. So often a deferred closure of the fistula must be done, thus amounting after all to a two-stage operation. These objections are of no great basic importance and they are offset by the good results obtained by many surgeons who use the method.

(Fig. 6.) Often a growth near the pelvic floor is too low to allow a safe or satisfactory anastomosis. The patient may be too feeble to allow the added strain of lowering the pelvic floor as described by Rankin. The disease may be removable by dividing the bowel with the cautery below the growth, inverting the rectal stump, and turning out the diseased area which can then be burnt off at a suitable level to leave a satisfactory end colostomy. Often in the aged, particularly in the male, this will prove a safer procedure than combined abdominoperineal excision and quite as



satisfactory. One should take care never to bury the rectal stump below the peritoneal floor unless the patient is turned after the abdomen is closed and drainage established to the ischiorectal fossa. If the stump is turned in flush with or above the peritoneum from within the abdomen, drainage is unnecessary unless there has been accidental contamination of the pelvic retroperitoneal tissues. If one leaves a blind stump of rectum, it is necessary to caution the patient to cleanse this segment at least once a month, otherwise a firm white accumulation of mucus will collect, causing occasional diarrhea from the colostomy through the nerve impulse of defecation or an uncomfortable feeling of pressure in the perineum. This may be avoided, if it presents a real problem, by dividing the sphincter muscles completely, thus allowing the secretion to escape as it forms.

The five-year curability has been calculated for the eight-year period 1925-1932. Counting all lost cases as dead, 71 per cent of those patients surviving a radical resection of a right colon cancer were alive five years after operation, 40 per cent with one of the transverse, and 37 per cent of those with a cancer of the left colon. If operative deaths are included, the five-year curability percentages are 47 per cent, 28 per cent, and 25 per cent respectively.

#### SUMMARY AND CONCLUSIONS

Carcinoma of the colon is a favorable site for cure, yet it accounted for at least 11 per cent of the deaths from cancer in the United States during the year 1936.

The disease produces early characteristic symptoms that should be recognized by the physician and by the patient.

The earlier the operation, the safer the procedure and the better chance for cure.

The average delay between onset of symptoms and admission to the hospital in our group was eight months.

Radical resections were possible in 58 per cent of a group of 618 admissions.

The mortality from radical operation was approximately 20 per cent in one-stage as compared to 13 per cent in the two-stage procedures.

The greatest percentage of five-year cures was in the right colon—yet the mortality of operation in one stage is much greater on the right than on the left bowel.

Aseptic resections particularly with two-stage Parker-Kerr anastomosis gave the lowest mortality.

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# EXAMINATION AND CLASSIFICATION OF TUMORS OF THE RECTUM AND COLON

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## *Initial Treatment of Operation Specimen.*

The French have a proverb, "C'est le premier pas qui coûte," which may be translated "The first step counts most." This is as true for the examination of operation specimens of intestinal tumors as it is of many other things in this world.

This first step is to open up the intestine with a pair of scissors along the anterior midline, gently washing away any intestinal contents with tap water. Then without further delay the specimen should be pinned out on a cork mat or sewed to a frame. The opening up and pinning out must be done before fixation with formalin. The operation specimen should never be placed direct into formalin or other fixative fluid. This would be a step in the wrong direction, because immediately after fixation the tissues begin to shrink and would become so distorted that it would be difficult to get a good surface view of the growth and the surrounding mucous membrane. It is not essential that the specimen should be opened up and pinned out immediately upon its removal from the body. It can be left for several hours provided that it is left severely alone, unwashed and unfixed.

We have a rule at this hospital that as soon as the rectum or colon is removed in the operating theater it is sent direct to the laboratory in a dish. The laboratory technician on duty then opens it up and sews it to a frame and sends back to the theater the pinned out specimen, washed and soaking in dilute formalin so that the surgeon may see it at the end of the operation.

The frame is shown in the accompanying photograph. (Fig. 1.) It consists of mecanno perforated strips with adjustable cross bars. Attachment to this frame is secured by

stitching with needle and twine, the sutures being kept taut so that the intestine retains its natural length and breadth. In operation specimens of cancer of the rectum the ligature which the surgeon ties round the inferior mesenteric pedicle should also be tied to the upper end of the frame to keep the vessels taut. Stretched on this frame the intestine should be immersed for one to two days in a tall jar containing ten percent formalin.

## *Examination of Operation Specimen.*

After the operation specimen has been fixed it may be taken from the frame and washed thoroughly with water. It is then inspected and certain measurements recorded. These include the total length of intestine removed, the size of the tumor, and its character (i.e., whether it is fungating, flat, or ulcerated); the quadrants of bowel affected; the relationship to anatomic landmarks such as the anorectal line, or the peritoneal reflexion, and the amount of free margin of bowel at the proximal end.

The next step is to form an estimate of the extent of local spread. Some information on this question can be obtained by feeling the perirectal or pericolic fat adjacent to the growth. The impression formed in this way should be checked later by cutting a slice transversely through the tumor at its point of maximum ulceration. The margin of the tumor is usually quite easily seen when the growth is sliced in this way. (Fig. 2.) In the case of rectal cancer the special points to notice are whether or not the growth has spread by direct continuity through the rectal muscle into the perirectal fat, and if so, to what degree.

*Local Spread.* As a general rule it will be found that the more deeply ulcerated the tumor, the greater will be the extent of

local spread in the perirectal or pericolic fat. Cancer begins within the mucous membrane and forms in the first place a nodular

layers of the growth becomes impaired and ulceration commences. Further infiltration of the bowel muscle and spread into the



FIG. 1. Operation specimen of cancer of rectum stretched on frame ready for fixation. (From Gabriel, Dukes and Bussey, in *Brit. J. Surg.*, 23: 395, 1935.)

projecting growth slightly raised above the adjoining surface. As the growth continues the tumor spreads by extension on the surface and by invasion of the underlying tissues. Increase of the malignant tissue proceeds in both these directions at the same time, but in some tumors the surface extension is slight, in others massive.

Invasion of underlying tissue results in an alteration in the surface contour of a tumor. This does not become noticeable while the growth is limited to the mucous membrane and submucosa, but as the malignant tissue pushes its way into the circular muscle the nutrition of the surface



FIG. 2. Longitudinal slice through wall of rectum showing local spread of carcinoma into perirectal fat and large lymphatic metastasis above. (From Annual Report, British Empire Cancer Campaign, 1935.)

perirectal or pericolic fat results in deeper ulceration.

In the case of cancer of the rectum the facts about local spread may be expressed in a few words. The extent of growth in a longitudinal or lateral direction can be seen from the surface. The extent of deep penetration can be estimated from the depth of the ulceration. Flat or projecting tumors are not likely to have spread far beneath the surface but deep ulceration is always a sign of deep extension.

**Lymphatic Spread.** The lymph nodes lie in the perirectal and pericolic fat and the adjacent mesentery, the connecting lymphatic vessels running near the veins. The

first lymph nodes to be affected in cancer of the rectum and colon are the regional group. Therefore, as many of these as can be found should be removed for microscopic examination. It is important also in the case of rectal cancer to remove separately for examination any lymph nodes found near the point at which the inferior mesenteric or superior hemorrhoidal vessels have been ligatured. The first direction of lymphatic spread in all rectal cancers (except growths situated in the lower third) is upwards along the hemorrhoidal lymph chain. If metastases are found in the regional lymph nodes only, and the upper hemorrhoidal glands are free, the prognosis is better than if all the lymph nodes contain metastases.

If the pathologist can find time for a more thorough procedure he will find that the interest of the case is increased both for himself and for the surgeon if he is able to make a map to indicate the position and size of each metastasis. This method has been developed by my colleague, Mr. H. J. R. Bussey, who makes a natural size drawing of each operation specimen sent for examination at St. Mark's Hospital, and records the exact position and size of each lymph node. As far as possible each node is bisected and one half taken for section, the other being left in situ, but with smaller nodes it is necessary to take all for section. The lymph nodes are blocked in batches. After microscopic examination the position of the metastases is marked on the map by inking in the affected places. The drawing is then photographed, and a photograph of the tumor itself and also of the gland dissection are attached to the pathologist's report. (Fig. 3.)

**Venous Spread.** A search should be made also for evidence of venous spread. This may take the form of a widespread permeation of the perivascular lymphatics or of thrombosis and growth within the veins. It is not common to find extensive spread within the veins, but if this is observed and confirmed by microscopic

examination it may be taken for granted that the patient has hepatic metastases.

**Form of Pathologic Report.** The pathol-

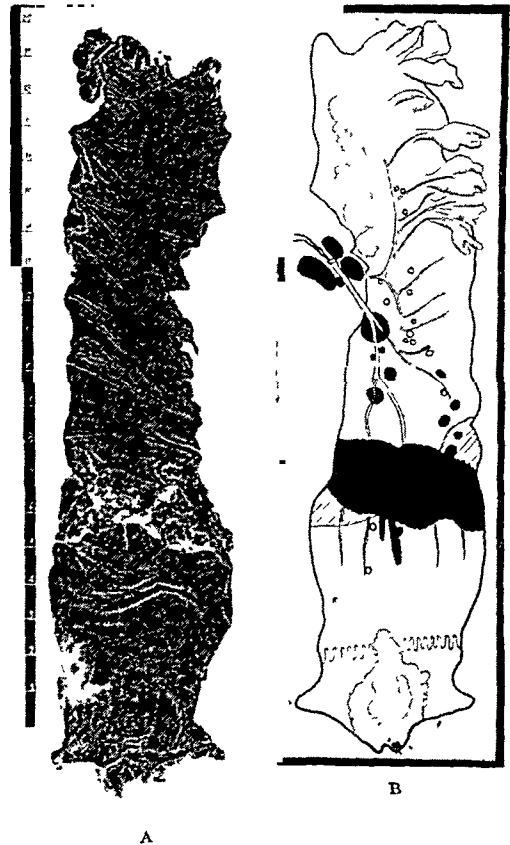


FIG. 3. A, surface view of operation specimen. An ulcerating tumor completely encircles the rectosigmoid. B, photograph of gland dissection. The primary growth and glandular metastases are marked in black. (From Dukes in *J. Tech. Methods & Bull. Internat. A. Med. Museums*, 15: 46, 1936.)

ogist's report should describe the size and position of the growth and its histologic character. It should also describe the extent of the local spread and state whether there is any sign of venous dissemination, and give some idea of the number and position of the lymphatic metastases. If the information is set out in this way the report will answer two questions in which the surgeon is deeply interested, namely: (1) How fast was the tumor growing? and (2) How far had it spread?

**Rate of Growth.** The rate of growth of cancer of the intestine is reflected in the histology of the tumor. As a general rule, a

growth which is well differentiated in character, closely resembling the tissue from which it is derived, is relatively benign and

ited to the rectal wall and there is no spread in the perirectal fat. B cases are those in which the growth has spread by direct con-

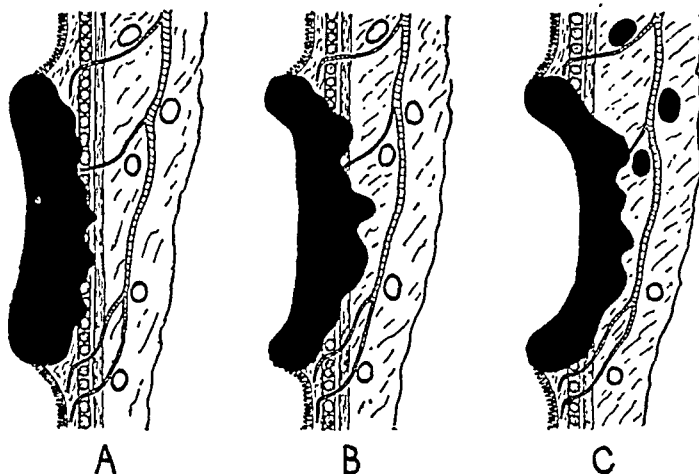


FIG. 4. Classification of cancer of rectum. A, growth limited to wall of rectum. B, extension of growth to extrarectal tissues but no metastases in regional lymph nodes. C, metastases in regional lymph nodes. (From Dukes in *Proc. Roy. Soc. Med.*, 33: 25, 1937.)

proceeds comparatively slowly. On the other hand a growth which is very poorly differentiated, having little resemblance to its parent tissue, is undoubtedly highly malignant and grows at a rapid rate. Broders (1925 and 1928) put this system of classification on a more exact basis by defining four grades of malignancy according to the degree of differentiation of the tumor cells. The value of this method of classification has been confirmed by several writers including myself (1937). The information derived from grading is particularly useful if the tumor is found to be either grade 1 or 4. Grade 1 tumors grow very slowly and metastasize late, whereas grade 4 neoplasms grow very rapidly and metastasize early.

**Extent of Spread.** If the examination of the operation specimen has been carried out in the way described it is possible also for the pathologist in his report to answer the second question: "How far had the growth spread?" At this hospital we divide cancer of the rectum into three groups—A, B, and C—according to the extent of spread (Dukes, 1932). (Fig. 4.) Cases of group A are those in which the cancer is lim-

tinuity into the perirectal fat but the lymphatic glands are free from metastases. C cases are those with lymphatic metastases. Table 1 shows the results of perineal excision in the three groups, the figure in the last column being obtained from the customary fraction:

$$\frac{\text{Alive at 5 years} \times 100}{\text{Operation survivals less those untraced and died from other causes}}$$

TABLE 1  
RESULTS OF PERINEAL EXCISION AT FIVE YEARS  
CLASSIFIED ACCORDING TO EXTENT OF SPREAD

Classification of Growth	Total Number of Cases 1927-May, 1930	Died from Operation	Died under Five Years		Un-traced	Alive at Five Years	Per-cent-age of Five Year Sur-vivals
			Of Other Causes	Of Can-cer			
A	24	..	2	2	..	20	91
B	36	1	5	10	2	18	64
C	34	6	3	21	..	4	16

# SUMMARY

This paper describes how an operation specimen of cancer of the intestine should

be pinned out and fixed. It describes the method of deciding the extent of local and lymphatic spread. If the specimen is examined in this way the pathologist is able to record the size and position of the tumor, its rate of growth (histologic malignancy grade) and its extent of spread (A, B, and C classification).

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It is fair to state that all patients having symptoms from internal hemorrhoids can be given relief in greater or less degree by injection of the hemorrhoids.

The brief excerpts in this issue have been quoted from "The Rectum and Colon" by E. Parker Hayden (Lea & Febiger, Philadelphia).

# EXPERIENCES WITH RESECTION OF THE COLON AND THE ELIMINATION OF COLOSTOMY\*

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RESECTION of the large intestine may be indicated for specific or non-specific granulomatous disease, for ulceration, diverticulitis, polyposis, other benign tumors, but especially for that very prevalent condition, cancer. In no other internal organ with the exception of the larynx is cancer as curable by operation, and in only one other is it as common as in the colon. Intrinsic cancer of the larynx has a nearly 100 per cent operability rate, and with an operative mortality of about 3 per cent, hardly 15 per cent of the growths recur after laryngectomy. Despite many delays in diagnosis from 60 to 80 per cent of the cancers of the large bowel now are operable when the patient is hospitalized. The operative mortality for patients who have not reached the stage of complications such as obstruction, perforation or metastasis has with the experience and the technical improvements of recent years been reduced to about 10 per cent or even less. After radical resection about 40 per cent of the patients remain free from evidence of recurrence after five years. In contrast, hardly 20 per cent of patients with carcinoma of the stomach reach the hospital while radically operable, and scarcely three out of one hundred are living and free from the disease five years after the operation. Grouping the types of cancer of the uterus and adnexa treated by irradiation, operation or both, a 30 per cent survival five years after initial treatment is very creditable. The better results from hysterectomy for the less malignant and rarer adenocarcinoma of the corpus uteri are outweighed by relapses after irradiation or operation for carcinoma of the cervix or ovaries. Nephrectomy for malignancy of the kidney has an even lower curability

rate from the predominance of tumors of the hypernephroma type over the less diffusible papillary cancers of the renal pelvis. By contrast the patient with early cancer of the colon has a particularly hopeful outlook with much more to lose from delay in diagnosis or defect in treatment.

The treatment of carcinoma of the colon is the early and radical removal en masse of the affected segment with 7 cm. or more of normal appearing bowel on each side of the tumor; together with the associated mesentery, tributary lymphatics and if possible any other involved tissues. The presence of small metastatic nodules in the liver or of enlarged cancerous glands along the aorta, does not in my opinion always contraindicate the removal of a resectable primary tumor. By the removal of the original growth the patient is largely relieved of obstructive symptoms, hemorrhage, foul discharge, absorption from the sloughing tumor and invasion of adjacent parts, and usually shows a marked improvement mentally and physically. Often he is able to resume his work for a year or more, and finally passes out after a relatively painless decline.

In 252 operations for cancer of the colon we found metastasis to the liver in thirty-three. In twelve the invasion of the liver was far advanced or the primary lesion irremovable. A palliative colostomy was done in six and a simple exploration in six. In the remaining twenty-one patients the primary growth was resected with three deaths (14 per cent mortality). A proctosigmoidectomy with perineal anus was done in thirteen, a Mikulicz-Paul stage resection in six and a resection with end-to-end anastomosis in two. Of nineteen pa-

\* From the Surgical Department of Temple University, Philadelphia.

tients surviving the operation most have lived over a year, four over two years, one woman now 75 years old is active and comfortable after four and one-half years.

Carcinoma of the large bowel may exist for two years or more without metastasis. In our series, symptoms such as colic, melena, change in bowel habit in the form of diarrhea or constipation, or physical evidence of the growth had existed for from a few months to over five years before the patient sought relief by operation.

The spread of cancer of the colon is chiefly through the lymphatics and portal circulation. Our experience confirms the findings of Miles that the lymphatic drift from cancer of the bowel is upward. We recall no case of lymphatic invasion caudal to the lesion in the bowel, nor in our series have we observed gross evidence of involvement of the inguinal lymphatics, even from anorectal growths. Metastasis to the skeleton is much less frequent (5 per cent) than to the lymphatics or liver, but may occur early. Quite striking is the relative, slight tendency toward peritoneal diffusion as contrasted with carcinoma of the ovaries, stomach and other organs. Even with colonic growths of long duration it is usual to find only small peritoneal nodules in a radius of but a few centimeters on the peritoneal leaflets adjacent to the tumor. In contrast is the predominant local invasive tendency of the cancer. It tends to ulcerate early, to invade the submucosa and muscularis to the peritoneum, and later to attach to and invade adjacent structures, as the bladder, small intestine, vagina, uterus, broad ligament or abdominal wall. Beginning in the transverse colon we have seen attachment and local invasion of the pancreas and a simultaneous perforation and proliferation in both the stomach and small intestine. In such cases if there is no clinical evidence of metastasis we have resected the involved colon with the attached involved uterus or involved portions of vaginal wall, bladder, small intestine, stomach, pancreas or other removable tissue.

The tendency in many cases for carcinoma of the bowel to remain localized for many months should stimulate the surgeon to undertake a very radical procedure even though excision has been considered impossible at a previous operation, and although a palliative colostomy has been done. Formidable adhesions may be found quite benign and infiltrative thickening about ureters and great vessels only inflammatory. I know of few situations of carcinoma in which a previous opinion of inoperability should so often be discounted. On the other hand, too frequently we find the rarely mistakable infiltration of cartilaginous hardness, the "frozen" pelvis, or the soft grayish material of a degenerated carcinoma invading parts that are not surgically removable.

The local invasion of the growth has two important clinical applications. The base of the ulcer is commonly thin and easily perforated by biopsy, or the necrosis produced by radium, fulguration or electric desiccation. We have seen the secondary peritonitis and localized abscess following a biopsy block an attempt at radical extirpation of the carcinomatous bowel. The malignant ulcer has such an unmistakable clinical picture with its hard, infiltrating, ragged, raised and rolled borders and central, depressed, irregular crater that the diagnosis can very positively be made by palpation alone. Nearly as reliable is the appearance of the growth as seen through a proctoscope.

I have never seen a mistake made in diagnosing an ulcerating rectal carcinoma by palpation alone, and therefore consider a biopsy both dangerous and unnecessary in this type. Should biopsy be used, only a portion of raised border above the level of the floor of the ulcer should be removed. With projecting polypoid or adenomatous growths a biopsy is relatively safe and is desirable, as with benign clinical features histologic evidence of malignancy may be found. Likewise, except to remove small superficial or polypoid adenomatous growths or to restore temporarily a lumen



through an obstructing irremovable fungating cancer, treatment by electrical destructive or other local measures should be strongly condemned. Local treatment not only fails to remove involved lymphatics, but histologic studies show the fallacy of attempting to destroy the primary carcinoma without the full thickness of the bowel. The treatment may reduce bleeding, delay or temporarily overcome intestinal obstruction and thus give the patient a measure of relief and much hope of cure. As with irradiation we find these patients after months of dangerous delay drifting to the surgical clinic for operative relief. A rather long duration of life may erroneously be ascribed to the treatment.

Patients with cancer of the colon who escape a fatal obstruction or perforation not infrequently live four or five years and some an equally long period after metastasis has developed. One of our patients with rectal cancer who was refused operation because of extensive metastasis in the pelvic bones lived five years and was quite comfortable until the last six months of his life. A woman now 75 years old, at the time we resected the colon, January 6, 1935, had metastatic nodules in the liver, yet she now considers herself in good health for her age. As her tumors had doubtless existed for some time before the operation it is evident that any harmless treatment used might have been credited with the prolongation of life. Even in young patients, symptoms referable to the disease may apparently cover several years, as in the case of a very robust and muscular man of 24, who for about three years had as his only symptom occasional transient attacks of severe obstructive intestinal colic after excess in eating. Finally after attending three parties and eating three lunches in one afternoon he developed complete obstruction and at operation an advanced carcinoma of the colon was found.

*Irradiation* by x-ray or radium has in no case of which I have personal knowledge been curative. Heavy irradiation used before or after operation I consider harmful

and in several instances it has left patients who otherwise would be well with distressing vesical, intestinal and cutaneous changes and an irradiation neuritis, which usually torments the patient as long as he lives. A few patients with advanced intestinal cancer think they have obtained a little solace from a very mild and relatively innocuous irradiation.

*Spinal anesthesia* has been used in nearly all our resections of the colon without mortality or serious complication thanks to our very efficient assistants. Although 37 per cent of our patients were between 60 and 79 years of age, serious postoperative pulmonary complications, except from metastatic growths, have been infrequent. The intradural injection of 100 mg. of pontocaine mixed with 55 mg. of procaine is favored on account of its prolonged action. As a rule this is immediately followed by 100 to 250 c.c. of a 1 per cent epinephrinized procaine solution, injected locally. During the operation, if the patient is asthenic, from 500 to 1,000 c.c. of 5 per cent glucose, possibly followed by 300 c.c. of typed citrated blood, is slowly run into a vein. Especially for secondary operations upon patients in very poor physical condition evipal and glucose infusion, combined with local anesthesia, have been very satisfactory to the operator and of great comfort to the patient. A slow intravenous infusion of 5 per cent glucose is started and continued during the operation. As the patient slowly counts, a 2.5 to 5 per cent solution of evipal is injected through the rubber tube close to the intravenous needle, at the rate of about 1 c.c. every ten or fifteen seconds. When the patient stops counting, the evipal is instantly discontinued, the abdominal incision quickly made and the abdominal wall and subperitoneal layers freely infiltrated with a 1 per cent solution of procaine containing 1 minim of epinephrine to each 10 c.c. With a pump syringe and a 20 or 22-gauge needle, from 250 to 500 c.c. of the solution are quickly injected. With this combination little additional evipal may be required and an asthenic patient may doze

through an operation lasting an hour and a half from a total of only .6 or .8 Gm. of evipal. If the injection is made at the ankle

and especially indicate the desirability of a direct approach by an oblique muscle-splitting incision placed over the lesion.

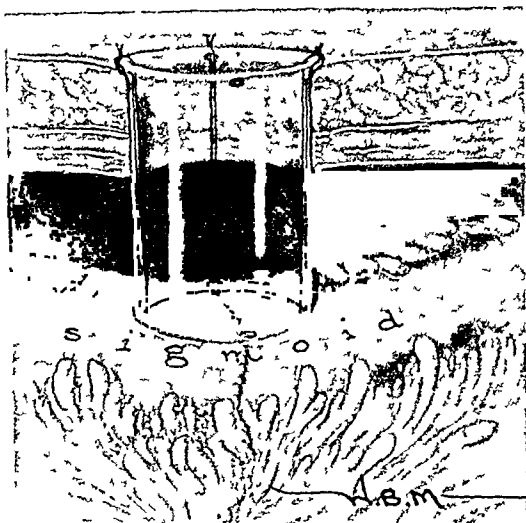


FIG. 1. Glass lamp chimney drain, attached by four wire sutures over an intestinal anastomosis. The drain is not fastened to the skin.

the body should be tilted head downward, as otherwise a dangerous accumulation of the drug in the lower extremity may occur before an appreciable effect is noted. If indicated, carefully typed citrated blood follows the glucose infusion.

It is not uncommon to find the patient in better condition at the end than at the beginning of an extensive operation, and in no case during recent years has sufficient shock occurred under either method of anesthesia to prevent the completion of a radical one-stage operation.

**Incision.** During recent years for resection of the colon for malignancy or inflammatory disease we have used oblique lateral incisions of the muscle-splitting rectus retracting type almost exclusively. Exception is made if a scar from a previous operation lies adjacent to the operative field. The excision of such a scar better enables the division of postoperative adhesions, the possible correction of an incisional weakness or the avoidance of additional complications in the abdominal wall. Fever, leucocytosis, induration of the parietes, tenderness or fixed mass suggest infection, pericolicitis, perforation or abscess

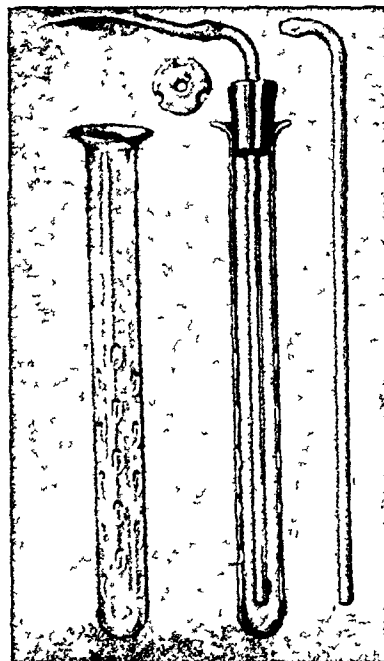


FIG. 2. Sump drain for the continuous evacuation of blood and other fluids that collect in the abdomen after an operation and that might lead to a spreading peritonitis.

Through such an incision infiltrated abdominal wall may be resected, an abscess may be drained, infected bowel delivered and necrotic tissue cared for with the least possible contamination of the general peritoneal cavity, and with the lowest percentage of hernias from a drained or contaminated wound.

These incisions run parallel with the fibers of the external oblique muscle and nerves of the abdominal wall and even after drainage usually leave a fine linear scar. (Fig. 6.) Additional room, if necessary, is obtained by dividing the anterior and, where present, the posterior sheath of the rectus, and by retracting or dividing the rectus muscle. The lateral extension of this type of incision gives good access to the deeply placed ascending or descending colon and facilitates the liberation and exteriorization of the bowel in a Mikulicz type of resection.

The alloy steel wire sutures with which we began to experiment in 1932 have proved of great advantage for closure of

drain the septic gall-bladder. The device so nearly eliminated the mortality from operating for cholecystitis that the large

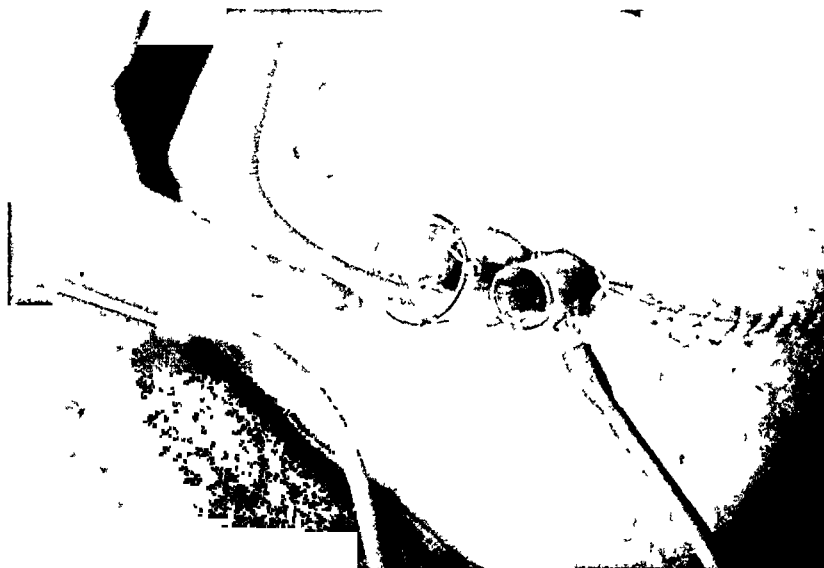


FIG. 3 Sump and lamp chimney drains with suction tubes guarding the suture line after a resection and anastomosis of the splenic flexure of the colon. Secondary intestinal leakage occurred in this case but with spontaneous closure of the fecal fistula and recovery.

the bowel or abdominal wound. (Fig. 5.) They do not hold or transmit infection, do not irritate, rarely form fistulous tracts, and therefore do not delay the healing of an infected wound. Either no anesthetic or only a little local anesthetic is required for the secondary stages of a graded operation, the bowel being without pain fibers.

For the right half of the colon a direct anastomosis has in our experience given a lower mortality than the Mikulicz type of operation, for both benign conditions and malignant tumors. Conversely for the left half of the colon the Mikulicz operation is considered safer than a one-stage anastomosis with a functional bowel. While the mortality from an end-to-end anastomosis in the left colon and sigmoid may be reduced by the use of "lamp chimney" and "sump" drains, we yet feel that the exteriorization stage type of operation is here safer, as it is in any case in which there is pericolicitis or abscess.

The "lamp chimney" drains came into use in 1935 in our attempts to exteriorize and later, after adhesions had formed, to

glass tubes were then anchored over other infected areas and also over insecure intestinal anastomoses. (Fig. 1.) By adding a soft rubber tube carried to the bottom of the drain, fluid welling into the chimney may continuously be aspirated (Fig. 3.) The need for the prompt removal of septic fluids, blood and other culture media, as well as any free peritoneal fluid which may lead to a spreading peritonitis, is especially great after resection of the colon.

From difficulties in obtaining "up hill" drainage, more recently we had the glass-blower fashion simple glass "sumps" of various sizes and shapes. (Fig. 2.) These consist of an external collecting glass well or tube which has multiple perforations so small as to prevent herniation of bowel or omentum of the adult. The internal aspirating tube may be of glass or rubber and is attached to a suction device, preferably a collecting bottle connected with a motor driven suction pump, although a water spigot aspirator or Wangenstein apparatus may be used. In the hospital machine shop we have had the miniature

motor and pump assembled as a stopper for a wide mouthed collecting bottle. (Fig. 4.) This forms a portable single unit

nections. It is obvious that the outer end of the collecting tube must remain open for the free entrance of air.



FIG. 4. Electric motor with suction pump and collecting bottle attached to glass sump drain for continuous aspiration of an abdominal wound.

for nearly any aspirating service and uses but one tube from the patient. When used for an abdominal resection of the colon the suction drainage should be started during the operation and continued during the first twenty-four or forty-eight hours or until there is no further collection of fluid. It is especially important to remove blood so promptly that clots do not form and obstruct the tubes. The aspirating tube and any other tubes (catheter, enterostomy tubes) running from the patient or any pressure port on the aspirator should be marked plainly or so tagged as to avoid dangerous complications from wrong con-

Our present operative technique is as follows: The diagnosis of low-lying growths is made by the finger and proctoscope, or, for those above the pelvis, by barium enema and Roentgen study. Evacuation and decompression of the bowel before operation are obtained by laxatives and repeated irrigations carefully supervised. I have produced an acute obstruction by a large dose of castor oil.

For an unrelieved obstruction a cecostomy or appendicostomy is preferred as a preliminary ileostomy may lead to inanition from the heavy loss of water and nutriment, not fully compensable by diet,

transfusions and infusions. We have seen death follow the delayed closure of an ileostomy apparently from this cause alone.

drain) over the line of union, but not to the skin, with four fine alloy wire sutures. This tube is lightly covered with a gauze dress-

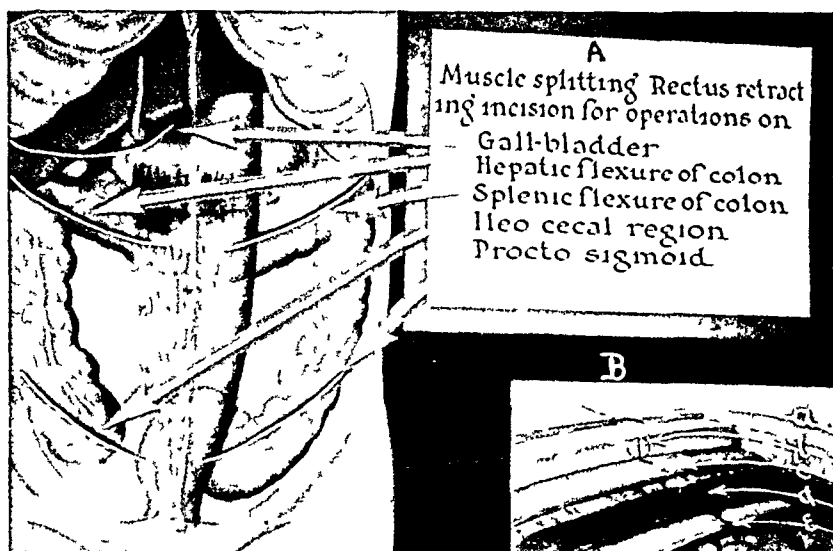


FIG 5. A, muscle-splitting, rectus retracting incisions used in resection of the colon. B, abdominal wound closure with annealed alloy steel wire: a, continuous sutures of 38 wire for skin; b, interrupted 35 wire sutures for subcutaneous fat; c, d, e, interrupted layer sutures for aponeurosis, muscle and peritoneum. The wire is tied in a square knot and the ends cut very short.

During the preparation the general condition of the patient is studied and he is fortified by fluids and a low residue high caloric diet.

**Selection of Operation.** In removing the cecum and ascending colon usually a one-stage operation with end to end anastomosis is used. This also has given us the best results in ileitis. Cutting the ileum obliquely and properly spacing the sutures compensates for a difference in diameter between the ileum and colon.

The inner one or two rows of sutures may be of continuous chromic catgut or of silk, but for the outer row we prefer the fine alloy steel wire (gauge 35 to 38), the ends being cut very close to the square knot. Our experiments show that adhesions form even over very fine (00000) catgut or silk exposed on the surface of the peritoneum, but not over the alloy steel wire. As infection or necrosis along the suture lines frequently occurs, especially after anastomoses of the colon we think it wise to anchor a tubular glass drain (lamp chimney

ing and through it the united bowel is inspected daily for change of color as well as for offensive odor or high bacterial content of the fluid exudate upon the bowel. If the exudate is free from bacterial contamination at the end of 48 hours the holding sutures are cut and the tube withdrawn. Offensive odor usually is followed by leakage along the suture line and indicates that the tube should be left in place for from five to seven days or until adhesions have firmly walled off the area. In several of our patients these tubes have provided an adequate vent for intestinal contents when leakage has occurred and apparently have been life-saving. The fecal fistula which then develops usually closes spontaneously after removal of the glass tube.

No other substance with which our group has experimented, except stainless steel, produces as little irritation in the peritoneal cavity, as does glass. Buried in a dog's abdomen a glass tube remains free from plastic adhesion or exudate at the end of two weeks, while a rubber tube is then

encased in dense adhesions, and ulceration through the intestinal wall has started. It is to be remembered that isolating adhesions form very slowly about glass drains, a very desirable feature when prolonged drainage of the general abdominal cavity is necessary.

The tubular glass drain over the sutured bowel may fail to function when leakage occurs on the mesenteric surface or that opposite to the tube. If this is feared a curved suction drain should also be introduced to protect this area. Such a concealed leak may be suspected when the bowel and attached tube become elevated in the wound evidently from pressure from beneath the bowel; or by the pain, tympany, nausea, rising pulse and temperature, and the evidence of free gas and liquid in the abdominal cavity. The treatment is the prompt reopening of the wound and the exteriorization of the bowel ends to prevent further intraabdominal leakage. In many cases a proximal enterostomy also is desirable to relieve the associated inflammatory ileus, and suction (sump drains) should be introduced through the wound, and if there is turbid or odorous fluids, also to dependent portions of the abdominal cavity.

A side-to-side anastomosis is preferred by many operators for ileocolostomy as it conveniently enables the formation of a large stoma. The end of colon and ileum projecting proximal to the anastomosis should not exceed 5 cm. in length and should be securely inverted and well vascularized, as there is a tendency for the blind ends, especially that of the ileum, to become distended and to leak or cause colic.

For several years we have not used a side-to-side anastomosis. Resections in the transverse colon are complicated by the attached gastrocolic omentum and great omentum and by the lack of blood supply when the transverse colic artery is divided. In an obese person particularly, it may be difficult to free the colon from its fatty encasement without interrupting the circulation. In such a patient a Mikulicz opera-

tion may not be very practical even at the flexures and we have observed that along the bulky folds of retained fatty omentum,



FIG. 6. Scar from oblique muscle-splitting incision used for one-stage abdominoperineal resection of proctosigmoid with perineal anus.

infection may be carried from the open wound into the peritoneal cavity with resulting fatality. As a rule resection of the transverse colon except at the flexures should be complete. In the obese patient also an end-to-end anastomosis in the transverse colon is particularly subject to necrosis and leakage.

Anastomotic resections of the descending colon and sigmoid have a greater incidence of infection and leakage than those of the right colon, and therefore a higher mortality unless the fecal current has previously been diverted. As a result and also because the area is beyond the liquid absorbing part of the colon it is here that the Mikulicz-Paul type of operation is especially indicated.

For colonic malignancy the operation has been criticized and discarded as insufficiently radical. We have modified the technique so that a radical operation may be done and the convalescence shortened, as follows: (1) The cancerous bowel, mesentery and other attached invaded tissues are liberated wide of the growth and exteriorized en masse. The wide removal of

malignant tissue, an essential part of the operation, is much more important than the peritonealization of denuded surfaces or the formation of a long spur for later division. (2) If the arms of the liberated loop of colon can be apposed without tension, they may be sewed together along *anti-mesenteric* borders. Usually the sutures cause tension and may tear out or perforate the bowel and I omit them. (3) A narrow sump drain is introduced to be left in for twenty-four to forty-eight hours to keep the cavity free from blood and serum. (4) the wound is closed only with layer interrupted alloy steel wire sutures and ligatures to minimize infection. With a protective dressing in place the exteriorized mass is immediately cut away between clamps. (5) A right-angled glass tube with well rounded lower border, and attached Penrose rubber drain is then tied in each bowel end—*above the skin level*. (6) These glass tube vents are removed when leakage from necrosis occurs, usually from the fourth to the sixth day, and wet dressings of a 1 to 500 permanganate of potassium solution are applied and frequently changed to deodorize discharges. (7) After seven to ten days the necrotic bowel ends are trimmed, and gently liberated from the skin and subcutaneous fascia for suture. Where the arms of the loop of the bowel have been held in apposition by the closure of the wound a short spur has formed. This spur is divided a centimeter at a time, the edges being united with a follow-up suture of interrupted 35 or 36 alloy wire in a fine curved needle. By traction on the last two sutures introduced, the spur is elevated and stretched, facilitating further incision and the introduction of additional sutures. Care is taken not to open the peritoneal cavity. Finally, the bowel ends are united as far as is feasible with inverting wire sutures. The skin and fascia are left open, separated and elevated from the sutured bowel by a light gauze packing and the wet permanganate dressing continued.

The steps of the Mikulicz operation have thus been modified from such unfortunate

experiences of myself or colleagues as: death from leaving an obstructive colostomy clamp on the bowel for two or more days; ischemic perforation and death from applying a spur clamp over the mesenteric border of the bowel or from using a devascularized loop; death from pressure perforation due to an indwelling colostomy tube and fatal spreading pyoderma of the abdominal wall from failure adequately to drain the subcutaneous fat after a Mikulicz operation.

In the method just described, as the spur is divided under vision and the edges united by sutures, there is less danger of perforation and leakage and much less necrosis than when the crushing clamp is used. The suture method is nearly painless and relieves the patient of the days of distress and sloughing accompanying the use of the clamp. From the short loop used the union obtained is often more of an end-to-end anastomosis than the side-to-side junction of the Mikulicz procedure. Occasionally with the wire sutures we have had the bowel closed and the patient ambulant by the twelfth day after operation, but usually several steps are required.

*Colostomy.* As nearly all patients object to an abdominal colostomy, I have given much attention to the preservation of a perineal opening. With resection of the colon above the midsigmoid this is not difficult, and with involvement of the lower sigmoid and even the rectosigmoid junction by carefully liberating the pelvic colon to the floor of the pelvis, it is at times possible by traction to deliver the upper rectum through a lower left inguinal incision with sufficient room below the growth to apply a clamp close to the skin and remove the involved segment. An angled glass tube is at once tied in the proximal end of the sigmoid and the cancerous loop with attached mesentery excised. Should the cancer involve much of the rectum, or the patient have a thick abdominal wall, an adequate excision by this method may be impossible, in which case the delivery and removal of the liberated rectosigmoid through the perineum is the preferred

operation. In a woman of 77 with very friable tissues, the rectum below the carcinoma parted. It was cleansed by passing antiseptic gauze through to the anus from above and a large cylindrical glass drain anchored over the open end of the rectum with four alloy wire sutures. The proximal rectosigmoid was excised, with formation of a colostomy. An uncomplicated recovery followed.

It is well recognized that resection of the obstructed colon has a high mortality unless the bowel is first decompressed by a colostomy, ileostomy or appendicostomy two or more weeks before the major operation. The appendix may be used provided it has a sufficient lumen and the obstruction has not reached a critical stage. It is delivered through a short muscle-splitting incision which is closed about the appendix without constricting or dividing the meso-appendix. The tip of the appendix is then amputated and a small soft rubber catheter threaded into the cecum which is gradually decompressed by repeated gentle irrigations, first with warm saline and later with a 5 per cent solution of peroxide of hydrogen. By daily withdrawing the catheter and substituting a well lubricated one of larger size, we have been able to insert a 27°F. rectal catheter through the appendix at the end of a week.

In many middle aged or elderly patients, however, the appendix is too atrophic to be used and a portion of the distended cecum or lower ileum is withdrawn through the muscle-splitting incision, a segment isolated and emptied with the aid of a non-traumatizing, curved rubber covered clamp. Two concentric purse-string sutures of fine silk are then introduced in the wall of the bowel, within which under the protection of surrounding pads, a puncture is made, and a 14 F. soft rubber catheter introduced and tied in. In closing the wound about the catheter it is best to use only alloy steel wire sutures and ligatures. The ends of the outer purse-string suture are brought outside the wound and tied around the catheter, after having also been

used to anchor the bowel to the overlying edge of peritoneum. Under repeated and prolonged irrigation after the patient has been placed in a comfortable position in bed, the small catheter will usually be found adequate for the decompression of the obstructed bowel.

If the free peritoneal fluid is turbid or shows evidence of bacterial contamination, a long narrow sump drain should be introduced through the wound to the bottom of the pelvis and suction evacuation continued as long as liquid comes away.

This simple enterostomy with a small catheter having several openings is preferred because the introduction of a mushroom catheter is more difficult, necessitates a larger opening, and there is risk of greater contamination in the wound. From a larger and therefore stiffer rubber catheter we have seen fatal perforation of the bowel due to pressure of the tip of the catheter. In our experience the mortality of a formal colostomy with exteriorized loop for ileus from cancer of the colon is about 15 per cent or over. Where there has been a heavy impaction of solid feces above the obstructing carcinoma while a simple enterostomy and persistent irrigation will relieve the acute and dangerous symptoms, flushing from any single opening may be inadequate to liquefy and evacuate the nearly solid mass. Even with a through and through flushing alternately, discharging first from the rectum and then the proximal enterostomy, hours of effort perhaps repeated over several days and the use of many gallons of water may be required before the colon is emptied.

Devine\* uses the proximal or the distal part of the transverse colon for the colostomy, unites the intra-abdominal arms of the loop with sutures and brings the ends of the divided colon through the recti and overlying skin by stab wounds placed 4 cm. apart. A month later the cancerous segment is excised. Realizing that it is not

\* Sir Hugh Devine, Operation on a defunctioned distal colon. *Surgery*, 3: 165, 1938.



possible to sterilize the malignant area, he advocates one year's delay before uniting the resected bowel. Finally, the colostomy openings are enabled to close by introducing a blade of a special crushing clamp through each of the openings which creates a by-pass between the arms of the loop. The special advantages of the Devine procedure are the small and well separated colostomy openings which are distant from the operative field and are in some measure controlled by the pressure of the surrounding rectus muscles, the avoidance of a permanent colostomy and especially the empty, functionless bowel during the operative period. Objections to the method are the difficulties in forming the provisional colostomy in an obese patient, the four different operations required, and the fact that fifteen or more months are required for the completion of the various steps. Previous operators who have used a colostomy as a preliminary stage to the removal of the growth while they may have separated the openings and employed cleansing irrigations have, especially where the pelvic colon was involved, usually made the colostomy a permanent one.

In any such multi-stage procedure it should not be forgotten that each stage has its mortality and when the deaths from the separate operations are added, as they should be, the aggregate mortality is often higher than that from a single stage operation. The sterilization of a sloughing carcinoma of the bowel by irrigation of course is not to be expected.

Due to the prevalence of cancer in the sigmoid and pelvic colon this part is resected more frequently than any other portion of the intestine. The rectum, anus and lower sigmoid may be removed through the perineum, but the procedure has several objections. It will fail, unless combined with an abdominal operation, to remove invaded lymphatics about the brim of the pelvis or disclose other serious conditions in the abdomen, while in any extensive perineal liberation the blood supply of the portion of the bowel brought down usually

is so interfered with that necrosis and the final formation of a narrow cicatricial and incontinent perineal opening results. The perineal operation has therefore fallen into disfavor, and largely has been replaced by a combined abdominoperineal procedure with the formation of an abdominal colostomy. Nevertheless, I believe that the perineal operation should be selected for anorectal and rectal growths in patients whose general condition indicates either a short expectancy of life or that the abdominal operation would be unduly hazardous, such as from marked obesity, advanced age or serious organic disease. The perineal operation also seems permissible when the growth is small, accessible and of the more superficial or less malignant type.

In the removal of the carcinomatous bowel through the perineum, while the posterior vaginal wall has frequently been resected, during recent years we have not removed parts of the sacrum or rarely even the coccyx. The mortality is lower than that of any other resection of the large bowel, and with routine irrigations and perhaps the insertion of dilators, many of these patients live in relative comfort, although, as would be expected, the percentage of recurrences is greater than after the more radical abdominoperineal resection.

As for the abdominoperineal proctosigmoidectomy which is the preferred procedure for cancer of the lower sigmoid and pelvic colon, I believe that a single stage operation with perineal anus may be as radical, more aseptic, rather easier of execution and better for the patient than the conventional multiple or single stage procedures with the formation of a permanent abdominal colostomy. In general, surgical opinion contends that an operation without colostomy is less radical. However, in the operation we use, the ligations are placed as high, the section of bowel, mesentery and peritoneum removed is as great, and an associated panhysterectomy, or resection of the vagina, vesicles, prostate or pelvic floor is as feasible as with any

other operation. Moreover that the colostomy may not have been essential for a radical excision at the original operation is indicated by our ability to transfer such an opening from the abdominal wall to the perineum at a latter time.

The single stage operation with perineal outlet is done without crushing, dividing or opening the bowel until after the wounds have been sutured and dressings in place and therefore, should be more aseptic than one performed with an abdominal colostomy. In either case in the liberation of the cancer an inadvertent opening of friable bowel or an invasion of a septic focus may occur. That the patient prefers the perineal opening even without sphincter control is the testimony of those we have operated upon, as well as those who have had an abdominal colostomy transferred to the perineum. From about 110 such operations we have learned that a perineal sigmoidostomy has a convenience, an infrequent soiling and discharge of gas, and an expulsive power from the abdominal muscles unequaled by an abdominal colostomy. With regulated emptying of the colon, over one-half of the patients with the perineal opening can dispense with a protective pad and 85 per cent have infrequent soiling. With a few modifications the technique we now use follows the plan described in 1932.\*

A muscle-splitting, rectus retracting incision parallel with and about 3 cm. above the left inguinal ligament is preferred. A hand is introduced through the incision and the abdomen explored from the liver and periaortic glands to the pelvic floor. The peritoneal leaflets of the sigmoid and rectum are divided wide of the growth, the ureters identified by their trombone movements and the left superior hemorrhoidal and inferior mesenteric arteries doubly ligated and divided near their points of origin. The peritoneal incision is continued around the brim of the pelvis

and back of the bladder or cervix and the bowel, lymphatics and fat are separated by the hand from the sacrum and lateral pelvic walls to the pelvic floor. The middle and inferior hemorrhoidal vessels are divided well lateral to the bowel. The uterus and adnexa are freed with the bowel if invaded. If the vagina, prostate or vesicles are adherent to the growth, their separation is left for the perineal stage. At a point well above any evidence of malignancy, the mesosigmoid is divided to the bowel. If at this level the sigmoid is still viable as shown by pulsating or continuously bleeding vessels, a folded gauze tape 1 meter long is tied about the bowel and the ends packed against the floor of the pelvis. If the sigmoid is ischemic, the tape, which indicates the level for the artificial anus, is tied about the lowest segment of pulsating bowel.

Up to this time all effort has been devoted to the complete removal of malignant tissue. The next important step is to liberate 12 cm. (5 inches) of viable sigmoid or descending colon to reach from the posterior border of the pelvis to the perineal skin. To obtain this it may be necessary to divide the lateral peritoneal leaflet of the descending colon and other restraining bands. The liberated bowel is placed in the pelvis, the omentum pulled over the small intestine and the incision is closed in layers with interrupted 32 and 30 steel wire for the deep layers and interrupted continuous 35 and 38 wire for the skin. A sump drain is used only when there is contamination or unusual oozing. The rectum which had been irrigated and, just before beginning the operation, lightly packed with gauze wet with 3½ per cent tincture of iodine or tincture of mercuric chloride is now occluded by a purse-string suture about the anus.

Through an incision from the posterior border of the anus along the right side of the coccyx, the pelvis is entered and with the wound well retracted, the tape and attached liberated bowel and adnexa are withdrawn, taking care not to make

\* Babcock, W. W. The operative treatment of carcinoma of the rectosigmoid with methods for the elimination of the colostomy. *Surg., Gynec. & Obst.*, 55: 627, 632, 1932.

traction upon the friable cancerous mass. A perforated curved glass tube drain with small perforations is inserted along the

the anal ring posteriorly and then to place the sigmoid in the mucous-lined anal groove. For fear of perforation the sigmoid

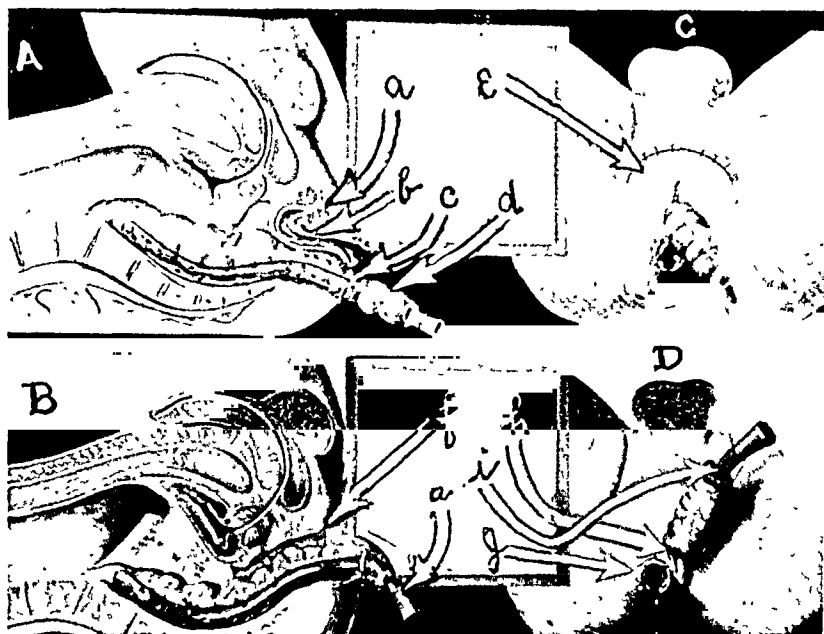


FIG. 7. One-stage abdominoperineal proctosigmoidectomy with perineal anus. A, the diseased loop of bowel has been liberated from above, then delivered through a median post-anal incision and removed. B, the perineum, pelvic floor and rectosigmoid have been removed after liberation from below. C, for an invading anterior proctosigmoid cancer the pelvic colon and infiltrated portion of the prostate have been delivered through an anterior perineal incision and removed. The sigmoid has been brought through the remaining anus which has been split anteriorly to relieve tension. D, the pelvic colon and sigmoid have been delivered and removed as in A, but the rectum has been amputated just above the sphincters, and the withdrawn sigmoid laid in the gutter formed by splitting the anus posteriorly. A glass pelvic drain is in place. a, anus; b, rectum; c, perforated glass drain; d, sigmoid; e, anterior perineal incision for anterior infiltrating cancers of the rectum; f, defect from excising pelvic floor by a wide elliptical incision; g, posterior split anus; h, rectal tube tied in sigmoid; i, posterior perforated glass tube drain extending along sacral curve.

hollow of the sacrum, dressings are applied and the bowel then cut away. A rectal tube is tied in the sigmoid end; a short glass tube with attached Penrose drain in the rectal end. The purse-string suture is then removed from the anus. The glass drain is withdrawn after twenty-four to forty-eight hours. On the seventh to tenth postoperative day the partitions between the sigmoid, rectum and anus are divided and the edges sutured, converting the three openings into one.

A desirable variation at the conclusion of the operation is to divide the aseptized rectum just above the sphincters and also

is not sutured to the skin or anus. Several patients have been out of bed by the tenth and have left the hospital by the fourteenth day after the operation. We also have used this operation for diverticulitis where the sphincters have been damaged.

If the carcinoma has penetrated the anterior rectal wall, an anterior perineal incision curving forward between the ischial tuberosities may be used, and the rectosigmoid delivered with any resected attached portions of vagina or of prostate or vesicles. (Fig. 7.) In this case the sigmoid is divided by cautery between clamps and pulled through the dilated and anterior

divided anal ring. If the perineal floor is involved the invaded portion is freely excised and removed with the attached

an abdominal incision. This proved to be a satisfactory and not difficult procedure.

The perineal opening enables the early



FIG. 8. Transfer of abdominal colostomy to perineum. A, the colostomy has been liberated and a cap of gauze and rubber has been tied over the end of the bowel with a folded gauze tape. B, the liberated bowel and traction tape placed against the floor of the pelvis for withdrawal through the perineum.

proctosigmoid. A retention catheter is inserted in the bladder before and not removed for several days after the operation. I have lost two patients from a hemorrhagic and necrotic cystitis following postoperative over-distention of the bladder.

In all cases posterior dependent drainage with curved perforated glass tubes carried through the perineum along the hollow of the sacrum should be used. Adequate drainage is the best prophylactic against spreading peritonitis in these cases. At first from using glass drainage tubes with an open end we had three patients in whom loops of small intestine entered and strangulated in the tube, with necrosis and secondary fistula in the perineum. The erosive discharge from these fistulas makes them very dangerous, as large blood vessels in the pelvis may be opened with fatal hemorrhage, as occurred in one case. Our experience has indicated that attempts to close such an intestinal opening through the perineum made matters worse and we would advise that the perforated loop be promptly liberated and closed through

detection of a pelvic recurrence by palpation. In six patients a recurrent nodule was thus detected and excised at a relatively early stage. Three of these patients are now living without palpable recurrence, from two to over four years after the last operation. Without the diagnostic advantage of the perineal opening, such recurrences may reach an inoperable stage before recognition.

As with an abdominal colostomy, the comfort of the patient with the perineal opening depends largely upon determining and utilizing the storage function of the colon. If the patient regularly empties the colon just before its capacity has been reached, he will as a rule then have freedom from evacuation for from twenty-four to seventy-two hours, apparently much longer than with a colostomy. Most patients obtain the best results from a physiologic saline or tap water enema taken in the morning or evening every twenty-four to seventy-two hours. For the seventy-two hour schedule a low residue diet the day after the enema followed by a full diet the

day preceding the enema often works well. About 20 per cent of patients prefer a small dose of a quickly acting saline such as one or two teaspoonfuls of sodium sulfate taken in a little cold water immediately on arising. Soon after breakfast, which includes a cup of hot coffee, the colon empties, after which constipation follows for the two or three days it is found feasible to wait before repeating the laxative. Mineral oil or laxatives of delayed or prolonged action should not be used. The perineal orifice should be of adequate size. A narrow or strictured outlet prevents the rapid and complete emptying of the colon, and consequently small, frequent and annoying discharges from overflow result. This should be overcome by dilatation, the patient daily inserting test tubes or other dilators. Protrusion of the mucosa of the sigmoid may cause an unpleasant local moistness, easily corrected without anesthesia by linear galvanocauterization or the injection of a few minims of a 5 per cent solution of quinine and urethane. A perineal hernia apparently is less common than the hernia often seen about an abdominal colostomy. In two cases, however, we have operated for such a perineal protrusion.

Ileus is an important postoperative complication of resections of the proctosigmoid. Where a pelvic diaphragm has been formed the small intestine may herniate between the stitches or by tension the mobilized peritoneum may so angulate the terminal ileum as to cause obstruction. In either case the abdomen should be opened and the obstructed loop released. In the one-stage operation we have described, no pelvic diaphragm is formed and a loop of small intestine may adhere in the denuded pelvis and angulate. Like the ileus which occurs in the immediate postoperative period after operations for inflammatory conditions of the abdomen or pelvis or for large hernias we consider the best treatment to be a simple ileostomy. The most distended coil is localized by physical signs (distention and tympany)

exposed by a short muscle-splitting incision and a No. 14 catheter with several perforations, tied in the loop. When the tension is released the obstruction usually disappears. If, on the other hand, the abdomen is freely opened and explored with separation of recent adhesions, these commonly soon readhere with return of the obstruction. Recent adhesions as a rule are too soft to produce necrosis of the strangulated loop. Quite different are the dense, well organized fibrous cords or bands, which produce an acute obstruction months or years after the abdominal operation which led to their development. The obstruction then often follows overeating or the use of laxatives and the great danger is from pressure necrosis, perforation and peritonitis.

Very recently a man, five years after a one-stage abdominoperineal proctosigmoidectomy with perineal anus, developed obstructive symptoms the night after heavy eating at a picnic. Three days later an emergency ileostomy was done and after an additional thirty-six hours, as this had not given relief, the abdomen was explored. Necrotic bowel which ruptured on delivery was found under a rigid fibrous cord in the pelvis. Such an experience is not very usual, and I would formulate a rule that an early postoperative ileus usually is best treated by a prompt enterostomy without separation of adhesions, while a late postoperative ileus indicates an immediate exploration and removal of the cause.

*Elimination of the Abdominal Colostomy.* An abdominal colostomy was transplanted to the perineum in seven patients. In four the colostomy had been a part of an abdominoperineal proctosigmoidectomy for cancer, in one patient eleven years, in another four years before. In the third patient the cancer had perforated the vagina and invaded the uterus and we had combined a panhysterectomy and resection of much of the vagina with an abdominoperineal proctosigmoidectomy and colostomy, seven months before. The

fourth patient had an en masse resection of uterus, appendages, upper vagina, rectosigmoid and 4 or 5 cm. of one ureter eleven

factory recoveries. The advantages of the perineal opening were very evident, such as ability to go without a pad or other pro-



FIG. 9. Cancer of the rectosigmoid and attached double-barrelled colostomy of the sigmoid withdrawn in one stage through a post-anal incision after closing the abdominal wound. A, cancer. B, colostomy openings covered with gauze and rubber dam. C, traction tape fastened to B. The bowel was adherent and two previous attempts at removal through the abdomen had been abandoned. The patient strongly objected to the abdominal colostomy.



FIG. 10. Hernia and intestinal prolapse from colostomy eleven years after Miles operation for carcinoma of the rectosigmoid. The redundant bowel and scar were excised, the hernia repaired, and perineal anus formed.

months before the transplantation. The fifth patient had vertical very adherent abdominal scars from two previous attempts to remove a cancerous rectosigmoid. On account of adhesions the growth had been considered irremovable and a double-barrelled sigmoid colostomy was done. Without disconnecting the openings in the sigmoid, adhesions were divided and the recto-sigmoid and colostomy liberated from above and then delivered through the perineum with the formation of a perineal anus. (Fig. 9.) All five patients had satis-

tection, evacuations occurring every two to four days instead of several times daily, convenience for irrigation, diminished flatus, and more effective expulsive action of the abdominal muscles. The remaining two patients were cachectic men. One, aged 60 had been treated for over a year by injections. A sigmoid colostomy for an obstructing anorectal carcinoma was done twenty-four days before an abdominoperineal resection with transplantation of the colostomy to the perineum. Despite preoperative evacuant measures the colon contained much impacted fecal material. The advanced adherent carcinoma ruptured in delivery. The patient died of a postoperative peritonitis. The seventh patient, aged 70, had a recto-

sigmoid carcinoma. On account of his great debility a two-stage operation was tried, a double-barrelled sigmoid colostomy being done at the first stage, and a proctosigmoidectomy with delivery of the bowel and of the colostomy through the perineum at the second stage fifteen days later. The patient died later from a necrotic metastatic carcinoma of the lung.

These experiences have confirmed our impression that it is easier and safer to do a proctosigmoidectomy in one instead of several stages, that any preliminary colostomy should not be in the field of the radical operation, and that while a permanent palliative colostomy for cancer of the rectosigmoid may properly be placed in the sigmoid, a temporary colostomy for intestinal obstruction should be in the cecum or proximal colon. It also was evident that it is safer to reoperate in the field of an old rather than a recent colostomy. With chronic obstruction in the terminal bowel a bulky fecal impaction may extend back to the cecum and be very difficult to remove by retrograde irrigation through a sigmoidostomy. In transferring a colostomy to the perineum, if there is a double-barrelled opening, it is usually better to isolate and ligate the ends of the bowel as one, covering the openings with a single protection of gauze and rubber drain, securely ligated in place rather than to divide the bowel.

*Technique of Transferring an Abdominal Colostomy to the Perineum.* The colostomy opening is plugged with antiseptic gauze and closed with sutures, and when liberated, the end of the bowel is covered by a cap of gauze and rubber dam securely tied on with a long tape. (Fig. 8.) The sigmoid segment and if necessary the descending colon are then sufficiently mobilized from peritoneal and other attachments to slide at least 12 cm. (5 inches) below the posterior pelvic brim. The soft tissues in the midline close to the sacrum are divided and then tunneled to the pelvic floor until a channel is formed through which the sigmoid may easily be drawn. The tape is packed in this tunnel, the end of sigmoid

laid over the opening and abdominal wound closed. With care not to injure the urethra or bladder the perineal scar is opened from below and the tape and attached sigmoid pulled through. A glass tube drain is introduced at the side of the coccyx or through the incision back of the sigmoid. A rectal tube is fastened in the sigmoid to prevent soiling during the first few days after the operation. The glass drain is usually removed in from twenty-four to forty-eight hours.

*Operability and Mortality.* Unfortunately, universal standards have not been adopted as to the operability of persons having cancer of large intestine. Personally I have attempted a radical operation in any case in which it offered a chance of prolonging the patient's life or rendering it more comfortable even though it could not be curative. Thus of about 265 patients seen during more recent years, operation was done in 252, which included removal of the cancerous segment in 212, an operability rate of 84 per cent, if we include patients not curable but relievable. In about 40 per cent of the patients symptoms indicative of cancer had been present over one year and in 21 per cent from two to even five years before the operation. At the time of operation 37 per cent of the patients were over 60 years of age, and 11 per cent between 70 and 79 years. As has been indicated, metastases were not uncommon in those considered to be radically operable. With such an exorably distressing and fatal disease as cancer the patient has little to lose, except pain, if given the benefit of every surgical doubt.

An enlarged lymph node in the field of the cancer is frequently found free from malignancy in the laboratory. Occasionally ominous physical signs, as fixation, the intense anemia of a cecal cancer, or a report from previous operation that the growth was adherent and irremovable, will be found due to a benign cause or to a malignancy that can be extirpated.

Mortality and our concepts of operability are closely related. Of the 252 patients forty-six, or 18 per cent, died after

operation while in the hospital. The highest mortality occurred in cases with perforation and resulting peritonitis, abscess or fistula: fifteen cases with nine deaths (60 per cent). Next was the mortality from direct anastomosis, nine deaths in twenty-six cases, almost entirely from resections of the functional left colon. While the mortality has been reduced by the recent use of better drainage, and while the operation is believed to be safer than a Mikulicz resection for the right colon, it has now been largely abandoned for the left side of the colon unless the fecal current has previously been diverted.

Colostomy—an operation under other circumstances of very low mortality—had a mortality of 30 per cent in the twenty-three advanced cases in which it was used as a palliative measure. The operation renders these patients disgusting to themselves and to their friends, who do not care to take them from the hospital and often leave them until they succumb to the

progress of the disease. Our present tendency is to do very few so-called palliative colostomies. In the face of obstruction we depend upon a low residue diet, irrigations, and duodenal suction. For the patient whose advanced disease leaves him but few remaining days we think it better to let him die obstructed than to inflict the nuisance of a colostomy upon him and his attendants.

The operative mortality is much reduced if we eliminate those shown by autopsy or otherwise to have been hopelessly diseased by metastasis or those that we have learned by experience were inadequately drained at the time of operation. Then the mortality in our series from abdominoperineal proctosigmoidectomy with perineal anus drops from 20 per cent to under 6 per cent, from perineal proctectomy from 11 per cent to under 4 per cent, and from the Mikulicz-Paul operation, from 15 per cent to about 5 per cent.





# MULTIPLE POLYPOSIS: CONGENITAL, HEREDOFAMILIAL, MALIGNANT

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**P**OLYPS occur throughout the colon in various numbers and at all ages.

As they, whether single or in numbers, are so often the origin of early malignancies, their importance is being more and more appreciated, hence early recognition and treatment of these growths, when benign, is good insurance against carcinoma.

Each word in "Multiple Polyposis" indicates plurality, and hence the caption is incorrect. Yet as it has been in use so long and is generally understood, I shall continue to employ it. Other terms such as adenomatosis, disseminated adenomata or polyposis, polypoidosis, agminated adenomata, polyposis intestini, multiple adenomata, colitis polyposa, and polypoid disease, appear in the literature. So many are confusing. Buie's designation of the disease, when more than one polyp is present, as multiple polypoid disease—to which he attaches the name of the anatomic portion of the colon involved—is no doubt more appropriate.

## CLASSIFICATION

The definition of a polyp implies that it is a pedunculated growth or tumor, but from usage now includes the sessile variety as well. Polyps in the colon are both pedunculated and sessile. In this paper multiple polyps only will be considered. Although perfect classification seems difficult, Erdman and Morris<sup>2</sup> have given us the one that has been, perhaps, most commonly employed in papers on the subject, viz., (1) the adult or acquired type; (2) the adolescent (congenital or disseminated type).

The adult or acquired type is assumed to occur only in adults and be due to some form of irritation. Yet we have all seen

multiple polyps in the infant, child or youth and felt certain they were not congenital. No doubt they also were acquired.

This type is the result of inflammation and is found most frequently with the different varieties of ulcerative colitis. Repeated clinical observations of colitis cases will easily demonstrate the truth of this statement, as the formation and growth of polyps can readily be followed through the sigmoidoscope.

The adolescent type, so far as the colon is concerned, is disseminated, heredofamilial and, I believe, congenital, continuing into adult life if the individual does not succumb to malignancy before then. I will consider multiple polyposis of the adolescent, congenital or disseminated type only.

A previous report of two family groups with multiple polyposis (referred to as Groups A and B) was made in May, 1936, before the Gastroenterological Section of the American Medical Association at the Kansas City Meeting.<sup>5</sup> These Groups, A and B, will be so designated in this paper also.

We attempted, when a case of polyposis was discovered, to contact and examine all other living members of each family group, whether with or without symptoms, and also to examine the records of those who had died. Some refused and still refuse examination and the survey is therefore not complete. No new cases are added.

The details of the findings in these two groups are given in Tables I to IV.

Recent correspondence would indicate that the health of four children of Group B (L. H., D. E., B. B., and L. B.) is not good and their complaints are not unlike those

TABLE I\*  
INCIDENCE OF MULTIPLE POLYPOSIS AND CARCINOMA IN  
FAMILY GROUP A

Group A: N. F.-♂; 47; ???; Died 47

S.F. ♂ 42 (MP)-C Died 44	F.M. ♀ 38 (MP) Died 41	A.C. ♂ 30 C Died 30	M.P. ♀ 27.	J.C. ♀ 21 (MP)-C Died 24	S.F. ♂ 20 (MP)
N.F. ♂ 10 (MP)	F.F. ♀ 8	E.F. ♀ 6	F.M. ♀ 16 (MP)	G.C. ♂ 11	S.C. ♂ 7
L.C. ♂ 5	R.A.C. ♀ 2				

Key to Tables I and III: S. F. ♂ or ♀, initials, sex; 42, patient's age at examination or on records; (MP)-C, multiple polyposis and carcinoma; Died 44, age at death; (MP), multiple polyposis; ?, needs watching; ???, history; M.P.?, Carc.? or both?

\* After McKenney, in J. A. M. A., 107: 1871, 1936.

TABLE II  
GROUP A

Members family group studied....	15
Found to have multiple polyposis..	6 (40 per cent)
M.P. cases died of carcinoma.....	2 (33⅓ per cent)
Clinical diagnosis carcinoma (not counted).....	1

TABLE III\*

TABLE III

Group B: A.C.H.-♂; 44; (MP)-C; Died 44

C.E.H. ♂  
34  
???  
Died 34

Ra.H. ♂  
38

L.H. ♂  
11  
(MP)  
Continued

M.M.H. ♂  
10

K.C.H. ♂  
7

G.H. ♀  
18

A.H. ♂  
17

I.H. ♀  
15  
?

G.H. ♂  
13  
(MP)

F.H. ♂  
11

C.S.H. ♂  
36

Ru.H. ♂  
33  
?

J.H.N. ♂  
10  
Continued

M.E.H. ♂  
7

N.C.H. ♂  
4

R.L.H. ♂  
15

A.W.H. ♂  
13

B.A.H. ♂  
12

M.B. ♀  
29  
(MP)-C  
Died 29  
(Married to E. and B.)

L.I.Hi. ♀  
29

E.J.H. ♀  
21  
(MP)-C  
Died 21

A.E. ♂  
11  
(MP)  
\* 44

D.E. ♀  
9  
(MP)

B.B. ♀  
5  
(MP)

L.B. ♂  
2  
(MP)

A.D.Hi. ♀  
11

C.E.Hi. ♂  
7

\* After McKenney, in J. A. M. A., 107: 1871, 1936.

TABLE IV  
GROUP B

Members family group studied....	28
Found to have multiple polyposis..	9 (32.14 per cent)
M.P. cases died of carcinoma.....	3 (33⅓ per cent)

of A. E., the brother of the last three mentioned, who died recently. The brief record of this case which I shall give, is a rather typical picture of the course of the disease, only too often seen in the young person.

A. E., a white male, age 11 (one of the four children of M. B., Group B, Table III) was examined October 30, 1932. He had a history of three to five bowel movements daily for the past seven years; bright red blood with stools for two months; occasional pain in the right upper quadrant.

Examination showed a well developed, well nourished boy, not acutely ill. The abdomen was soft and not tender. Four plus blood was noted in stools. Eosinophilia was 8 per cent. Sigmoidoscopic examination revealed many polyps, 1 to 8 mm. in diameter, in the lower 10 inches of bowel, closely segregated about the colorectal junction.

*Treatment.* From November 2 to 5, 1932, the boy was given 300 Roentgens, but no change was noted following this therapy.

Examination on April 28, 1934 was essentially the same as in 1932. X-ray showed numerous polyps from the hepatic flexure to the rectum. Stools were negative for blood. (Fig. 1.) Biopsy of one of the polyps showed benign adenomatous proliferation. Treatment: 600 Roentgens over the anterior abdomen. On May 28, 1934, diarrhea and frequent emesis were reported. The patient was in bed part of the time.

July 29, 1934, he was apparently well. Sigmoidoscopy showed little difference in the polyps. Treatment of 600 Roentgens over the anterior and posterior abdomen was given. August 8, 1934, sigmoidoscopic examination showed the polyps very red, bleeding easily, with considerable mucus.

November 11, 1934, 600 Roentgens were administered. Biopsy showed "adenomatous proliferation well on the way to being malignant." The child was still well developed, however, and growing steadily.

By July 29, 1935, no untoward symptoms had developed, the bowels were regular with no blood or mucus. A further treatment of 600 Roentgens was given and biopsy showed "pre-malignant changes."

In April, 1936, I had a letter from his guardian which stated that the child attended school

regularly, had gained 11 pounds in seven months; had one to two stools daily with no blood or mucus. His appetite was good. Later in

Although the x-ray in April, 1934 had shown polyps from the hepatic flexure downward, few were seen at autopsy proximal to the



FIG. 1. A. E., male, age 11, showing characteristic mottling of multiple polyposis throughout the whole colon.

the month another letter stated that there was "difficulty in voiding; progressive swelling across the lower abdomen with considerable pain." The symptoms became worse and swelling increased. In August, the boy went to bed and remained there. Swelling broke through the lower abdominal wall in September and thereafter all bowel passages were through this opening. The urinary symptoms ceased but the patient rapidly became emaciated.

In October, 1936 I saw him, emaciated and failing rapidly, with small bowel passages and urine pouring from a wound in the abdomen. He expired November 11, 1936.

*Autopsy.* There was an opening 1 inch in diameter through the abdominal wall above the pubis, slightly to the left of the median line, through which fluid fecal contents and urine poured. A large abscess cavity occupied the entire pelvis, extending up over the posterior, superior and anterior walls of the bladder, opening through the hiatus mentioned. The small bowel formed part of the abscess wall and had perforated into the abscess cavity, as had the bladder. Below the rectal perforation the rectal mucosa was studded with many polyps, from 2 to 8 mm. in size. The heart and lungs were apparently normal; few enlarged lymph nodes were observed in the mesentery; liver, spleen, pancreas and kidneys showed nothing remarkable.



FIG. 2. F. S., male, age 35, showing mottling of multiple polyposis.

splenic flexure, but they were present from the splenic flexure to the rectal perforation, which might indicate slight benefit from the x-ray.

Sections taken from near the perforation in the rectum and examined by Dr. W. F. Jacobs showed necrosing carcinoma. Sections bisecting the bulbous tip and pedicle were made through each of eight polyps taken from above and below the carcinoma. In none was there any invasion of the pedicle or mucosa and the gland proliferation was definitely papillary adenoma.

The story of multiple polyposis, congenital type, is one of catastrophic events. A young mother, dying a horrible death from the disease with carcinoma, gives birth to a child in all probability doomed to a similar early fate. Young children, while seeming to be in fair health, suddenly sicken and suffer intensely a shortened life, to plunge into the agonizing death stage of carcinoma, short in point of time, but seemingly long because of the intense suffering.

A polyposis family group history is an ever changing one and the chronicler must not lay aside his typewriter, as the story must constantly be rewritten. The surgeon in charge of such a family has plenty of worries, knowing his limitations

in affording help because of: (1) the difficulty in getting coöperation from these patients; and (2) the difficulty of rendering

Autopsy revealed carcinoma of the lower pelvic colon with perforation, suppurative peritonitis and adhesions, polyposis of the

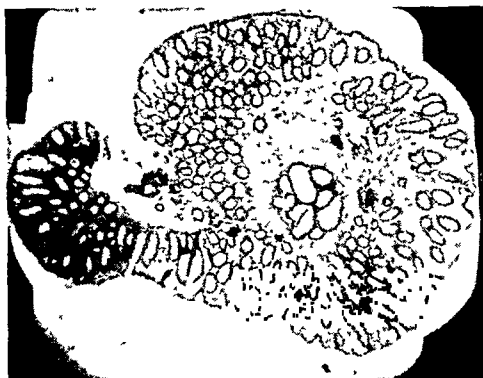


FIG. 3. F. S. Histology of typical polyp.

services productive of results desirable and satisfactory to both the patient and physician.

I wish now to add another family group, referred to as Group C, to groups A and B.

#### GROUP C

In May, 1925, before the American Proctologic Society in Atlantic City,<sup>4</sup> I reported a single case of polyposis the nucleus of Group C (Table v), of which the following is a brief summary:

A male, F. S., aged 35, presented himself for examination in September, 1924, stating that for ten years he had never had a formed stool. Instead, he had up to fifteen fecal-stained fluid stools a day without blood, mucus or unusual amount of gas. More recently he had developed cramps and was unable to work.

On examination polyps were easily palpated in the lower rectum, many were demonstrated with the sigmoidoscope in the lower 12 inches and by roentgenography (Fig. 2) throughout the colon.

Through the sigmoidoscope 600 of the tumors were removed and when two large ones at the colorectal junction were destroyed his cramps disappeared and he was able to resume his work.

Later he developed carcinoma in the lower pelvic colon (Figs. 3 and 4), followed by obstructive symptoms necessitating a colostomy August 19, 1928. He died October 7, 1929, of pelvic peritonitis due to perforation through the carcinoma.

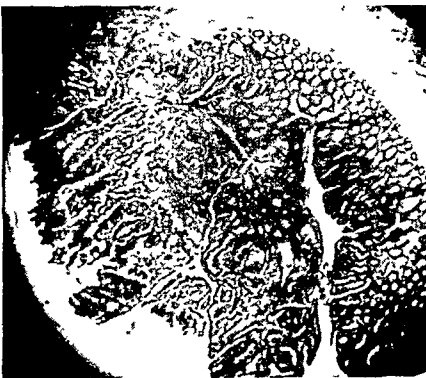


FIG. 4. F. S. Histology of typical polyp right; undergoing malignant change left.

entire colon, except the rectum where polyps had been removed and only occasional small ones were seen. The polyps were from pinhead

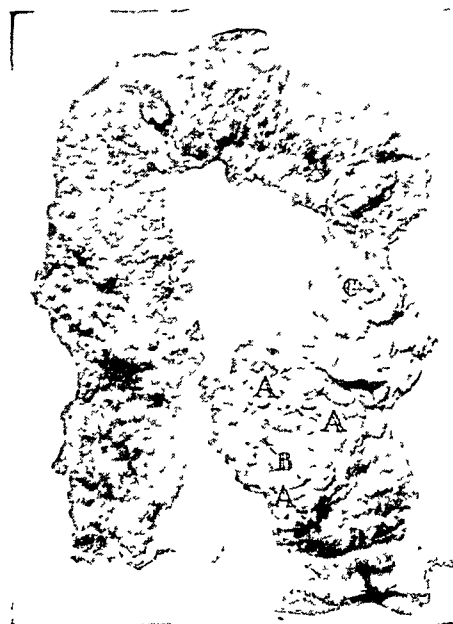


FIG. 5. F. S. Polyps of various sizes, sessile and pedunculated, throughout whole colon. A, carcinoma upper rectum. B, perforation through carcinoma which caused pelvic peritonitis. C, colostomy opening. D, practical freedom from polyps in lower rectum from which 600 had been removed.

to plum size, pedunculated and sessile, closely set everywhere throughout the colon. Broncho-pneumonia with beginning suppuration (Fig. 5) was also noted.

At this time every effort was made to get permission to examine the patient's child, his brothers and their children, but with no success at that time.



FIG. 6. L. C. V., female, age 22, showing the mottling of multiple polypsis through entire colon and a large polyp in the proximal transverse colon which caused an intussusception.

Eight years later, July 10, 1937, Mrs. L. C. V., age 22, (niece of F. S., who had died eight years previously) (Table v) presented herself with a history of good health up to the previous two years when she began to have eight to ten stools during the day and two or three at night. This had become worse in the previous three months, with much blood, pain in the lumbar region and right lower quadrant. She had lost 12 pounds in weight.

Examination revealed an adenocarcinoma running upward from the junction of the upper and middle thirds of the rectum, involving the anterior wall and sides. The polyps, sessile and pedunculated, were seen through the sigmoidoscope in the lower 10 inches of the bowel and demonstrated by roentgenography throughout the entire colon, with a cluster of polyps, or carcinoma, in the proximal third of the transverse colon. (Fig. 6.)

An appendectomy had been done in 1934.

The question arose, what to do with this girl. In consultation with Dr. T. E. Jones<sup>3</sup> of Cleveland, we agreed that as she was so young, the chances were that metastases had already taken place and that surgery would be of no avail. Besides, if surgery were resorted to and, despite it, the patient died, it might discourage

treatment of the other members of the family, who, as I will show later, had the disease.

In September, abdominal pains obstructive in character developed and continued to get

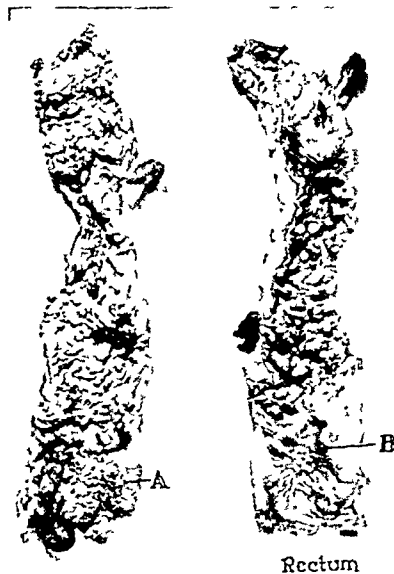


FIG. 7. L. C. V., polyps, various sizes, sessile and pedunculated. A, large polyp in proximal part transverse colon. B, carcinoma of rectum.

worse. Roentgen ray again showed in the transverse colon a tumor which had previously been palpated.

The patient refused operation until November 16, 1937, when pain became unbearable. Through a median lower abdominal incision the mass, as large as a lemon, was located in the transverse colon where it had caused an intussusception of the first part of the transverse colon into the middle third. (Figs. 6 and 7.) This was reduced without difficulty. A loop bearing the polyp was then easily brought out through the upper part of the wound and left outside the abdominal wall to be opened proximal to the polyp the next day. Unfortunately, the patient died a few days later of peritonitis.

An autopsy limited to the abdomen revealed multiple polyposis of colon, with few polyps in the rectum and with many apparently infarcted polyps, sessile, slightly ulcerative carcinoma in the upper part of rectum, large papillomatous polyp of the transverse colon at the site of colostomy opening, and diffuse, fibropurulent peritonitis. (Fig. 7.)

Figure 8 shows the histologic findings in a typical polyp. Figure 9, taken from the large polyp seen in Figure 7, shows atypical histo-

logic findings in a later with fecal vomiting. It is evident his trouble was intestinal; he died young; and two of his sons, as I will show later,

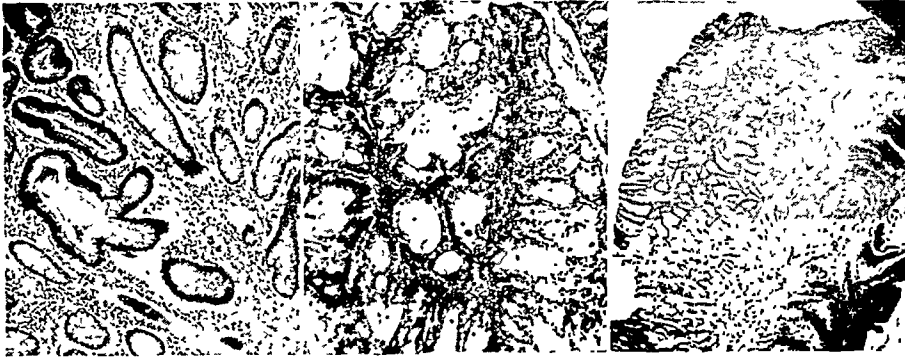


FIG. 8.

FIG. 9.

FIG. 10.

FIG. 8. Histologic findings in typical polyp.

FIG. 9. Atypical histologic findings in papilloma with marked glandular proliferation, hyperchromatic nuclei and mitotic figures (from Fig. 7A).

FIG. 10. Adenocarcinoma invading submucosa and muscularis (from Fig. 7B).

logic findings in papilloma with marked glandular proliferation, hyperchromatic nuclei, and mitotic figures. Figure 10, taken from the rectal tumor, shows an adenocarcinomatous invasion of the submucosa and muscularis.

had polyposis. These are three bits of incriminating evidence that his trouble was polyposis, or polyposis and carcinoma, rather than some trouble from the accident which had occurred six months before. There was no history of symptoms in the meantime which could be attributed to the accident.

G. S.'s wife is still alive, has no symptoms that might make one think of polyposis, but will not submit to examination.

G. S. had three sons. One, L. S., is said to have died of pneumonia at the age of 34. F. S. died of multiple polyposis and carcinoma. W. S. had multiple polyposis and died of a heart condition just recently. The latter had ten children, of whom three died in infancy and three more, so far as I know, are free from the disease. One of these may have it, as the examination in this case was very unsatisfactory. The oldest child, L. C. V., died of multiple polyposis and carcinoma, and three others, a girl aged 9, one boy aged 11, and another aged 13, all have polyposis and at the time of the examination in July, 1937 seemed quite well, except that each had two or more stools a day. Since then they have consistently refused examination. L. C. V. had no children. (See Tables v and vi.)

TABLE V  
INCIDENCE OF MULTIPLE POLYPOSIS AND CARCINOMA IN  
GROUP C

G. S. M ??? Died 34							
L. S. M Died 34		F. S.* M 35 (MP)-C Died 40		W. S.* M 44 (MP) Died 44			
A. A. S.* F 6	J. F. S.* F 9 (MP)	F. W. S.* M 11 (MP)	R. F. S.* M 13 (MP)	H. K. S.* M 16	H. M. S.* F 19	L. C. V.* F 22 (MP)-C Died 22	

Key: F. S., initials; \*, examined; M (or F), sex; 35, age at examination or on records; (MP), multiple polyposis; (MP)-C, M. P. and carcinoma; ???, history suggests M. P., carc. or both; Died 44, age at death.

G. S., grandfather of the previous patient, died at the age of 34. (Table v.)

From a very meager hospital record and from relatives I obtained the following history: He fell out of a hay barn on a machine handle and six months later developed a diarrhea with blood in the stools and vomiting. Following this (how long I could not learn) he had two operations in a hospital, dying twenty days

TABLE VI	
CLINICAL HISTORIES IN GROUP C	
66⅔ per cent multiple polyposis	
33⅓ per cent of the multiple polyposis cases died of carcinoma	
Members of the family group	9
Examined	9
Multiple polyposis	6
Ages when examined: 9, 11, 13, 22, 35, 44	
Average age	23.16
Males	4
Females	2
Of these 6 multiple polyposis cases:	
Died of carcinoma, ages 22, 40	2
Died, heart condition?: age 44	1
Alive, ages: 9, 11, 13	3

The three family groups are combined in Table VII. Fifty-two people were studied and 40.39 per cent of these were found to have polyposis; 38.09 per cent of these are now dead of carcinoma. (Table VII.)

TABLE VII	
SUMMARY OF THREE FAMILY GROUPS (A, B AND C)	
40.39 per cent had multiple polyposis	
38.09 per cent of the multiple polyposis cases died of carcinoma	
Members of the three family groups	52
Examined	47
Dead, records studied	4
Dead, history from family	1
Multiple polyposis	21
Ages: 2, 5, 9, 10, 11, 11, 11, 13, 13, 16, 20, 21, 21, 22, 29, 38, 40, 42, 44, 44	
Average age	20.52
Males	13
Females	8
Of these 21 multiple polyposis cases:	
Died of carcinoma, ages: 15, 21, 22, 24, 29, 40, 44, 44	8
Died, suspected carcinoma, age 41	1
Alive, ages: 2, 5, 9, 9, 10, 11, 11, 11, 13, 13, 16, 20	12

TABLE VIII		
AGE INCIDENCE OF GROUPS A, B AND C MULTIPLE POLYPOSIS, ADOLESCENT TYPE		
Decades	Cases	Ages
1-10	5	2, 5, 9, 9, 10
10-20	7	11, 11, 11, 13, 13, 16, 20
20-30	4	21, 21, 22, 29
30-40	2	38, 40
40-50	3	42, 44, 44
Total	21	
Youngest		2
Oldest		44
Average		20.52

As examination was made of all members of a known polyposis family where permission to do so could be obtained, this table shows the disease present as one might expect in an exceptionally large percentage of young persons. Fifteen of the twenty-one were from 2 to 22 years of age.

CONGENITAL, HEREDITARY, FAMILIAL

My contention that the disease is congenital in origin is based on the following observation:

The study of four children in the same family, Group B, each with multiple polyposis, seems to bear out well the congenital theory. These children were respectively 2, 5, 9, and 11 years of age. The difference in the ages of these four children is approximately two and three-fourths years. The amount of increase in size of the adenomas of the oldest child over the next younger and of the latter over the next younger and so on down to the youngest is practically alike for each two and three-fourth years period. This, to me, would indicate that the youngest child, from the size of the growths found at the time of the first successful examination (age 2 years), had been born with the growths. Examination of the youngest child, L. B., when 1½ years of age, could not, because of resistance and lack of preparation, be accomplished with any degree of satisfaction, but six months later the polyps were easily found. (Fig. 11.)

A similar observation in Group c seems to point toward the congenital origin. Four children in this group, although not so young, were respectively 9, 11, 13, and 22. The size of the polyps of the 22 year old was at least four times that of the 13 year old, although one polyp had grown many times larger. The amount of increase in the size of the polyps of the 13 year old over the 11 year old apparently equaled that of the 11 year old over the 9 year old.

Also of interest is the fact that the size of the polyps in the 9 year old child in each of two groups (B and C) was practically

#### MALIGNANT TENDENCY

It has been my experience that pathologists find in many cases, where many

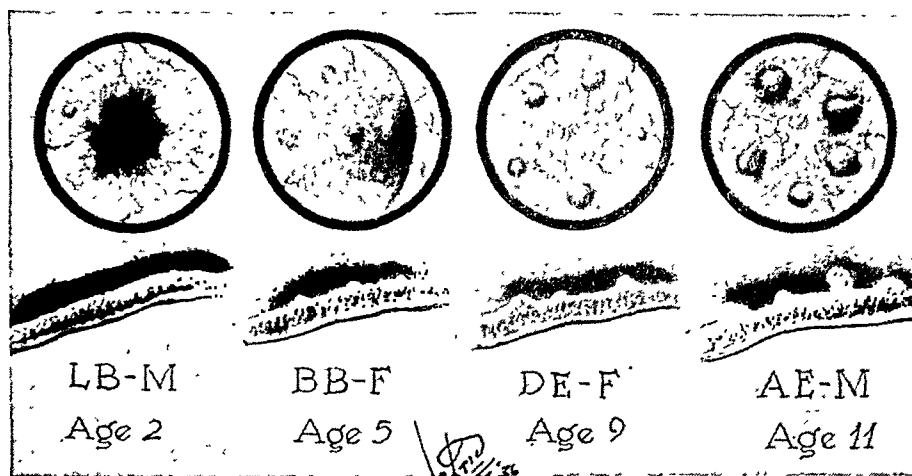


FIG. 11. Comparative size of adenomas in four children of one family, ages 2, 5, 9 and 11. As there is an average difference of two and three-fourths years in the ages and so nearly a like amount of growth for each period, it suggests congenital origin in the 2-year-old and hence in all. (From McKenney in *J. A. M. A.*, 107: 1871, 1936.)

the same. This is also true of the 11 year old children in each of the same two groups.

Only the examination of newly born children in known polyposis families will clear up this question. In infants, by following the technique outlined in the chapter on diagnosis, we can expect to find, not well formed polyps, but immature ones no more than a millimeter in diameter, showing just below the surface if they are present. Polyps such as these may also be found among larger polyps in older children, if carefully looked for.

That the disease is hereditary and familial is very evident. The transmission is through either sex. In group B (Table III) it was passed from father to daughter and, through her, to one son and one daughter by one husband and to another son and daughter by a second husband. All or only part of the children of one afflicted parent may have the disease. In group B it missed one generation to appear in the next.

So far, I have been able to trace the disease through three generations only. (TABLE III).

polyps from one patient have been examined, changes so suggestive of beginning malignancy that they hesitate to call all the polyps benign and advise constant watching. Their caution is well-founded considering the malignant change seen in my series.

Of twenty-one multiple polyposis cases in my three-family series eight are dead of carcinoma, i.e., a percentage of 38.09. Figures from various sources place the percentage at about 50. My feeling is that eventually malignant change will take place in every case.

Two others with polyposis have died, the one aged 41 with strong suspicion of carcinoma; the other, aged 44, is said to have died a cardiorenal death, although the pathologist some time previously reported "a very fast growing polyp." Neither case is included in the above figures.

My study of multiple polyposis began in September, 1924 with one case, and no more were seen until 1930. The one seen in 1924 and one other (from reliable records) had died just before 1930, while six more died in the nine-year period



after 1930, i.e., eight deaths from carcinoma in about ten years. The ages of the eight were 15, 21, 22, 24, 29, 40, 44, 44, an average of 29.87, while the average age of the eleven still living on June 1, 1939 is 16.82. Thirteen years from now the average age of the eleven living will be the same as that of the eight dead. Is it not reasonable to assume that the eleven will be dead in that length of time if nothing is done in the meantime to prevent it?

Buie says: "In at least half of these cases in which total polypoid disease of the colon is found, tissue can be obtained which will give evidence of adenocarcinomatous changes on microscopic examination." He also states: "So definite is the progress of histologic metamorphosis in all polyps of the colon that, given sufficient time, it is believed that all polypoid lesions of the colon, although not actually classified as malignant growths, should be treated as such and whenever possible destroyed promptly on their discovery."

In the examination of polyps no matter how many are returned as benign, the next may be cancerous. A negative report is of value in regard to the single polyp only. The chance of finding a malignant polyp for biopsy is greatly enhanced if one sees sudden rapid growth in a polyp that has been under observation. Carcinomatous degeneration of polyps is always very malignant and rapidly fatal, a factor in which, no doubt, the youth of the patient plays an important part.

The frequency of malignant change in multiple polyposis can only be correctly estimated when every member of a generation and at least two succeeding generations is examined, careful records kept and autopsies done on all who die, unless clinical and histologic study positively established a diagnosis of carcinoma before death. To accomplish this one surgeon should pass on his records to a younger successor, who by carrying on in the same manner will, after a few generations

have expired, be able to give authentic information.

Of course an examination and an autopsy on every one that dies cannot be hoped for.

I know of no one in my group that has passed the age of 44 with polyposis, so study over about a fifty-year period should be sufficient.

#### SYMPTOMS

In some cases, discovered in the adult, a history of two to even ten loose bowel movements a day without cramps, blood or mucus in the stools or other untoward symptoms, has existed for a number of years without any apparent impairment of health. In more instances, however, the adult presents himself with the severe symptoms of advanced polyposis or malignancy and a history of impaired health for some years.

In a child up to 6 to 8 years of age there may be no demonstrable symptoms other than perhaps one or two extra bowel movements a day. From this time on, up to about the age of 14, indefinite abdominal pains usually occur at irregular intervals. Slight increase in the stool frequency, with at first an occasional showing of blood in the stools, may also be noticed.

It is plain so far as symptoms are concerned, that, except for slightly increased bowel frequency, the disease can go unheralded during the early development of the polyps, longer in some cases than in others.

Later, increase in the number of stools, with blood and mucus, cramp-like abdominal pains, and tenesmus were found to be due to a large polyp, or the segregation of polyps at the normally narrow part of the colon, the colorectal junction, causing progressive obstruction with increased secretion of mucus. Intussusception is very likely to occur. Similar symptoms were caused, but less frequently, when the rectal polyps were large enough to exert more or less constant pressure on the push-button of defecation, the anorectal junction. This also occurred if they were large

enough to secrete quantities of mucus, which had the same effect when flooding and irritating the same push-button.

As malignancy occurs early in this disease, severe diarrhea with tenesmus, the passage of very frequent stools with much blood, mucus and gas, with marked anemia and emaciation, may be expected and looked for to indicate such a change. One of the youngest of my cases to develop carcinoma was A. E., who died at the age of 15.

Although blood in the stool occurs sooner or later, it may not be noticed for some time. It indicates injury to the polyps by the passage of stool, inflammation or malignant change. The bleeding may be from slight to profuse.

As observed by Buie, these symptoms are less pronounced when the polyps in the pelvic colon and rectum are removed. Especially is this true when the polyps are near the colorectal or anorectal junction. One of my cases, F. S., a male, who had been practically bedridden was, after such treatment (particularly the removal of two fairly large polyps from the proximal side of the colorectal junction), able to return to work and continue until he developed a carcinoma. (Fig. 5.)

#### DIAGNOSIS

There may be a history, early in the disease and for some years, of a slightly increased bowel frequency with loose stools, but no apparent morbidity resulting therefrom. This is followed later by recurring attacks of diarrhea, with blood, mucus, gas, cramps, and anemia; still later, when malignancy is superimposed, all these symptoms are greatly exaggerated. Although these symptoms are not characteristic of this disease alone, if one is aware that his patient comes from a polypoid family they become most suggestive.

The polyps can frequently be palpated digitally and, when large enough, some of the polypoid and sessile types may be distinguished. However, in the young individual, under 6 years of age, on account

of the small size of the polyps, this is practically impossible.

The routine use of the sigmoidoscope,



FIG. 12. Film of colon containing bran and simulating polyposis.

as advocated by proctologists, has made diagnosis possible at a much earlier age. The instrument opens to direct inspection with perfect illumination the distal 25 to 30 cm. of the bowel. With the lamp at one side of the distal end of the instrument, light is thrown across the field so that the tiniest polyp will cast a shadow, bringing it into relief and making it visible. A light thrown downward on top of the polyp, as from a lamp in the proximal end of the instrument, would cast no shadow and the growth might, perhaps, be missed.

Roentgenographic examination by double contrast media, barium followed by air injection, after the method of Fischer, modified by Weber,<sup>6</sup> defines the extent of the involvement, which in the case of the congenital type is practically always through the whole colon. A pathognomonic mottling establishes the diagnosis. It is well to bear in mind that this mottling may be simulated and puzzling to the inexperienced when bran has been eaten

and the bowel not thoroughly emptied. A cathartic will clear up the suspicion. (Fig. 12.)

The region of the lower pelvic colon is now no longer "no man's land" so far as diagnosis is concerned as it can be doubly examined by means of the sigmoidoscope from below and by improved roentgenographic technique.

All of my cases were diagnosed easily with the sigmoidoscope alone. The x-ray demonstrated the extent.

Occasionally a large polyp causes an intussusception and obstruction, with characteristic symptoms, especially if near a narrow part of the bowel such as the hepatic or splenic flexures or the colorectal junction. In such cases a tumor may be found on abdominal palpation. There may also be abdominal distention and vomiting. (Figs. 6 and 7.)

Diagnosis of this disease, to be of greatest value, should really be multiple, by which I mean that when one case is found the study should extend to other members of the family and to as many generations as possible. Because of the occurrence of carcinoma in polyposis cases at such early ages, special attention should be paid to the search for polyposis in all young persons found to have rectal carcinoma, especially those with family cancer history. With this clue many more polyposis families might be located. Should the carcinoma be low in the rectum the polyps may be obliterated by the growth and be difficult to find, in which case the sigmoidoscope should be carried above the tumor. Should it be necessary to do a colostomy, through this opening and with the same instrument, internal inspection can easily be made upward and downward in the colon. If the malignancy is fatal then an autopsy will clear up the diagnosis.

Diagnosis in most cases is not made until the patient is in the late stages of the disease, whereas it should be made earlier if we are to get anywhere in the treatment. The only way the diagnosis of many young persons with the disease can be made is

to examine all entitled to have it through heredity before symptoms compel them to seek medical advice.

#### DIFFERENTIAL DIAGNOSIS

Multiple polyposis of the congenital type has chiefly to be differentiated from the adult type, sometimes spoken of as "pseudopolyposis." In the latter, in my experience, the polyps have been rather few in number, irregularly distributed, and irregularly shaped, both sessile and pedunculated, with a tendency to be in clusters where ulceration was deepest and most extensive. A history of colitis and a finding of a shortened colon, a narrowed lumen, lack of haustration and active or healed ulcers in an adult should justify the diagnosis of this type.

#### TREATMENT

In my series, the youngest patient to die of carcinoma was A. E., aged 15 years, while the others died at ages 21, 22, 24, 29, 40, 44, and 44. It will be noticed that four were 24 or under. The average age of the eight who died was about 30 years. As it is impossible to anticipate the date of change from benignancy to malignancy, and, as carcinoma of the colon in the young person from its inception progresses very rapidly, any treatment to be successful must be employed early.

After diagnosis is made in young persons who apparently have no very annoying or untoward symptoms, it is difficult to convince them or their guardians of the seriousness of the disease and the necessity of treatment. Their decision is usually to leave well enough alone. Especially is this true if some member of the family, so afflicted, came too late for help and died while under treatment for alleviation of terminal suffering. This is regarded by the relatives as absolute failure of treatment, as is also radical treatment, should death follow it.

If these patients live to young adult life they have been accustomed to a certain amount of suffering for some time

and usually seek aid only when the severe symptoms of malignancy supervene.

In my series of cases the economic status of the patients stood in the way of treatment, but, even when this could be overcome, attempts at persuasion of the guardians to have a young person submit to operation, failed.

Three of the eight who died presented themselves with well advanced carcinoma, so that surgery was contraindicated. Another with carcinoma became pregnant and refused surgery for fear of aborting. She gave birth to a living child and died soon thereafter. Another developed a carcinoma, but refused surgery until obstruction made colostomy an emergency operation. Two died just before my study began. One aged 15, died on a farm a long way from Buffalo.

The high mortality from malignant degeneration warrants radical procedures in treatment.

To date the most successful treatment has been excision of the whole or a portion of the colon, and this, of course, should, if possible, precede malignant change. Such an operation is a formidable one and the danger of it, together with the dread of an ileostomy for the rest of life, is not a pleasant outlook for the patient.

In 1926, Dr. T. E. Jones<sup>3</sup> reported treatment of a female, aged 25, with congenital adenomatosis. He did a cecostomy, fulgurated the polypi in the rectum and sigmoid, following this by an ileosigmoidostomy and six weeks later a colectomy. Later the patient developed an adenocarcinoma in the retroperitoneal glands. His comment is "the moral of this case, of course, is to perform the colectomy earlier, as we lost about three years valuable time." He advises removing the polypi under spinal anesthesia in one or two sittings and performing the same operation as in this case as soon as possible.

From the patient's viewpoint the operation as performed by Jones, as it retains normal bowel control, is most desirable.

The polyps of the rectum and pelvic colon to the highest point reachable through a sigmoidoscope are destroyed by snare or fulguration. Then an anastomosis of the distal ileum is made with the highest point of the cleared area in the pelvic colon. This is followed by excision of the rest of the colon. An objection to this over complete colectomy is the possible development of carcinoma in the portion of the large bowel below the anastomosis, where normally the highest percentage of carcinomas occur.

Removal of polyps by fulguration seems to dispose of them very satisfactorily and I do not recall the recurrence of one that had been completely removed. However, there may be some new ones develop, for which reason, after the operation mentioned, the bowel up to the anastomosis should be watched carefully and kept clean by further fulguration as necessary.

If a colostomy is made on the left side, in the iliac colon or the upper part of the pelvic colon, through a sigmoidoscope passed downward through this opening polyps can be removed to the highest point to which it was possible to clear the gut from below upward. This makes it possible to make the ileocolostomy at a higher point in the large bowel. An objection to this is that, after anastomosis is made, and the colostomy opening (the inspection window) has been closed, it is impossible thereafter to observe and keep free from polyps (potentially malignant foci) that portion of the large bowel above the highest point that was cleared of polyps from below upward. Of course, should malignancy develop and, by symptoms and x-ray, be discovered in time, this portion of the large bowel can then be removed and a permanent ileostomy done.

A word of warning in the use of fulguration is desirable. Fulguration can, with the patient in the inverted position, be carried out through the sigmoidoscope in one's office without an anesthetic. This position permits the air to rush in

and distend the bowel, making visibility as nearly perfect as possible, providing the bowel has been completely emptied of fecal contents in advance. In this way only can be exercised the care necessary to prevent perforation of the bowel at such vulnerable points as above the colorectal junction, opposite the cul-de-sac, or opposite the prostate or bladder. Before attempting fulguration in a case of this kind, the surgeon should have mastered the technique and acquainted himself with all the dangers associated with the misuse of such a powerful machine.

The sigmoidoscope can be made of bakelite or some nonconducting material, although that is unnecessary if the electrode is well insulated throughout its length, except for the active tip.

One of the greatest means of insurance against danger is to have the field kept constantly free from smoke. To that end I have constructed a sigmoidoscope with a built in smoke-suction tube, which is connected with a suction pump and functions while fulguration is in progress. Of equal importance is to have attached to the same suction pump by means of rubber tubing a suction pathfinder, a tubular instrument with piston grip and a ball at the distal end, which can be used for the double purpose of guiding the passage of the sigmoidoscope and of keeping the bowel free from fluids.

Should one fear that he has injured the bowel, the patient should be kept where a laparotomy can be quickly done if perforation occurs. In case of hemorrhage, the lower bowel should be emptied with a cool water enema; this alone will often stop a moderate hemorrhage. If it does not, then the patient can be placed on a tip-up table and, through the sigmoido-

scope, the bowel can be further cleansed as necessary with water and the suction pathfinder, until the bleeding point is located. The open vessel should be grasped with a long alligator forceps and coagulated slightly. On top of this a pledget of cotton with adrenalin has, fortunately, in my limited experience, completed the hemostasis. A blood transfusion, which conceivably might in some cases be necessary, in all probability will favorably affect the hemostasis.

The question of sterilization of multiple polyposis cases arises. To be successful it would have to be applied to all children (male and female) of an afflicted parent, because of possible skip-transmission.

Where practically all the mucosa of the rectum and pelvic colon is covered with polyps, their fulguration would be such a tremendous task that complete colectomy with permanent ileostomy is preferable. The colectomy can be done in two or three stages as the experience of the surgeon deems safest for the patient.

Regarding irradiation as a method of treatment I am unable to add anything to my previous report.<sup>5</sup>

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## BOOK REVIEWS

**ENDOCRINOLOGY IN MODERN PRACTICE.** By William Wolf, M.D. Second Edition. Philadelphia, 1939. W. B. Saunders Company. Price \$10.00.

This large book of 1077 pages covers the field of endocrinology from every conceivable angle and brings the subject matter up to date. In every sense of the term it is a textbook, but one which is eminently readable. Any physician, whether general practitioner or specialist, can turn to it with profit.

The various glands and their diseases are covered in separate chapters. Other special chapters cover allied subjects, such as the menopause, pregnancy, menstruation, obesity and sterility. There is an elaborate discussion of laboratory procedures and their use in endocrine diagnoses, and a section on the application of endocrinology to non-endocrine disturbances.

This edition is far better illustrated than the first, but unfortunately still lacks a bibliography.

**TEXTBOOK OF GENERAL SURGERY.** By Warren H. Coleman, M.D. and Robert Elman, M.D. Second Edition. New York, 1939. D. Appleton-Century Company. Price \$8.00.

This work first appeared in 1936, but the authors have felt a new edition desirable to record more recent progress. The authors have remained of the opinion that the book should include only what they considered the most important details of general surgery "in such a way as to be of every day value to the practicing physician as well as to the medical student." In the new edition, obsolete or relatively unimportant material has been deleted or shortened. More important data, such as a consideration of sulfanilamide therapy, the prevention and treatment of bleeding in jaundice by vitamin K, mixed tumors of the lung, changes elucidating further the decompression therapy of intestinal obstruction (to name but a few) have been included in this volume.

Discussion of operative technique has been confined to a few of the more common types of operations, for the writers feel that "the fund

of surgical knowledge is becoming too vast to include surgical diagnosis and detailed operative data in one volume. (For) an inadequate and brief description of an operation might lead to the erroneous conclusion that certain procedures were simple and might be performed with inadequate preparation on the part of the surgeon." This statement alone would influence us to favor this book. The volume is 1031 pages long, has 559 figures, a bibliography at the end of each chapter, and an index.

**LA DERMATOLOGIE EN CLIENTÈLE.** By H. GOUGEROT, M.D. Sixth Edition. Paris, 1939. Maloine. Price 220 francs.

Gougerot, one of the great names in dermatology, has brought up to date in a sixth edition his book on the practice of dermatology. This forms part of a series on medical practice, in which different authors have written texts on the application of their specialties to the needs of average practitioners.

Dr. Gougerot, who is Professor of Dermatology and Syphilology at the Paris Faculty of Medicine, is a recognized authority on the subject. He has attempted in this volume to differentiate the known from the unknown, to simplify and present only the essentials of the subject. The book is 800 pages long and intensely practical in viewpoint throughout. It is well illustrated by over 300 photographs, many in color.

Like most French books, it is inadequately indexed, but an attempt has been made through an exhaustive table of contents, to indicate where various items may be located.

**TEXTBOOK OF PATHOLOGY.** By Charles W. Duval, M.D. and Herbert J. Schattenberg, M.D. New York, 1939. D. Appleton-Century Company. Price \$8.50.

The authors have written a book that stresses the relationship between pathologic physiology and altered tissue changes or morbid anatomy. They claim that "this permits of a better understanding of important clinical phenomena and their correlation with basic pathological

findings." The writers claim that pathology is a basic science, and that the student should be thoroughly grounded in histopathology before undertaking the study of disease from the clinical standpoint. With this the reviewer heartily agrees.

The subject matter is presented in such a manner that the theme of the text is the pathology of the living patient. This book has not been written along the lines of a "dead-house" subject. References from foreign literature have been purposely omitted and only those by English and American authors that are pertinent to the text are included. The subject is covered thoroughly and in detail. The reading is clear and easy.

In the 681 pages there are nearly 350 illustrations, many in color. The index is ample. All in all—everything to be desired in a textbook of this character.

**CANCER LARINGEO: SU TRATAMIENTO QUIRURGICO.** By Ricardo H. Bisi, M.D. Buenos Aires, 1938.

This monograph on the surgical treatment of cancer of the larynx is very impressive in scope and wealth of detail. The detailed illustrations are very clear and instructive. It deals thoroughly with the indications for operative and non-operative intervention of laryngeal cancer. Many useful points are given as to the pre- and postoperative care in laryngectomy.

**THE SCIENCE AND ART OF JOINT MANIPULATION.** By James Mennell, M.D. Vol. 1,—The Extremities. Philadelphia, 1939. P. Blakiston's Son & Co. Price \$4.50.

This book (233 pages) is different. It reveals in every chapter that the author is not writing a treatise on theory but a monograph on a subject with which he has had practical clinical experience. It is recommended to anyone who treats patients suffering from disorders of the joints of the extremities. The book sets a standard for teaching and practice in the science and art of joint manipulation and offers a standardized procedure for the technique of examination, diagnosis and treatment. The contents include a survey of joint lesions, referred pain, rules for manipulation, and studies of each joint by itself.

There are 284 illustrations and an ample index.

**CIRURGIA DO MEGAESOFAGO.** By Edmundo Vasconcelos and Gabriel Botelho. Sao Paulo, 1937. Companhia Editora Nacional.

This monograph on the surgical management of the mega-esophagus, by Professor Vasconcelos and Dr. Botelho, of the Medical Faculty of the University of Sao Paulo, Brazil, is a thorough, up to date study on a very important surgical problem. It consists of 401 pages in Portuguese, covering the history, theories, physiology, histology, pathology, diagnosis and surgical procedures of this annoying esophageal malady or lesion.

Were it not for the linguistic problem, this book should be in every medical man's library. Nevertheless, thoracic surgeons would do well to familiarize themselves with this important monograph.

**THE ENDOCRINE GLANDS.** By Max A. Goldzieher, M.D. New York, 1939. D. Appleton-Century Company. Price \$10.00.

Endocrinology is one of the foremost topics of medicine of the present era. Hardly a week passes but new discoveries in this field are made or new theories offered for consideration. It has become a complex, involved part of medicine, which calls for an understanding of some of the basic sciences and an appreciation of clinical realities. Therefore, this book by one who has devoted his energies to this field for over thirty years is welcomed.

The writer has utilized the recent advances in the field of physiology and pathology for practical purposes in the diagnosis and treatment of endocrine disorders, and offers simultaneously evidence to support the statements made. The book can serve as a source of references for those who desire additional detailed information.

In addition to stressing the morphology, physiology and morbid anatomy, the author presents a new and detailed classification of the endocrinopathies, and, in addition, discusses the prevalent methods of diagnosis and treatment.

This work contains 916 pages, with references following each topic. There are 271 figures and an index.

# The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

## EDITORIAL

### CAUSES OF ASPHYXIAL DEATH

ASPHYXIA has been described as, "a deficiency of available oxygen in the circulating blood, terminating fatally," or more simply, "oxygen want," or as described by Henderson, "asphyxiation is the process that occurs whenever it becomes difficult for the tissues to obtain their normal supply of oxygen. Any absolute deficit kills quickly. As exclusion of oxygen extinguishes a fire, so too in man or animal a deficiency of oxygen in the blood and tissues induces death by asphyxia."

The causes of asphyxial death may be approached from one of two viewpoints: from that of experimental physiology, and from that of clinical medicine.

The approach from the point of view of experimental physiology complicated by biochemical and pathologic variations indicates a wide etiologic field tied together by the common bond of "oxygen want." This approach was elaborated by Coryllos who in his recent article on asphyxia quotes from Meakins and Davis, seven causes of oxygen want:

1. Insufficient partial pressure of oxygen in the inspired air (high altitudes).
2. Obstruction of air passages or resistance to respiration.

3. Obstruction to the passage of gases from the alveoli to the blood (edema, inflammation, exudation, destructive lesions, emphysema).

4. Alteration of oxygen-carrying capacity of the blood (anemia, carbon monoxide, nitrate or chlorate poisoning).

5. Circulatory failure.

6. Pollution of the oxygenated blood by its mixing with the venous blood (uneven ventilation of the lungs, unaerated channels, congenital cardiopathies, and the like).

7. Inhibition of oxydative processes in the tissues (cyanide poisoning).

The approach from the viewpoint of clinical medicine proposes an integration of clinical diseases and accidents, tied together by the common bond of "the relief of oxygen want," or a common form of treatment which when correctly applied is calculated to save the life of the patient. When such clinical relief is not available, or is inefficiently applied the patient succumbs from asphyxiation, a typical example of asphyxial death.

The purpose of bringing about such clinical integration is to emphasize the importance of the combined causes of asphyxia and by such emphasis to bring to bear organized measures for prevention



and relief. When the various causes of asphyxiation have been assembled as a single generic problem a major medical condition is found to exist.

The Committee on Asphyxia of the American Medical Association reporting to the Board of Trustees lists the following causes of asphyxiation (*J. A. M. A.*, May 1, 1937).

1. Asphyxia neonatorum.
2. Asphyxia from gases used industrially.
  - (a) Carbon monoxide from illuminating gas and from engine exhaust.
  - (b) Refrigerants such as ammonia, carbon dioxide and dry ice.
  - (c) Fumes in the manufacture of chemicals.
  - (d) Gases associated with the oil industry.
  - (e) Gases in the mining industry.
  - (f) Fumigation for disease; the destruction of rodents on board ship and elsewhere.
3. Asphyxia from gases in warfare.
4. Asphyxia from drugs, hypnotics, narcotics, and sedatives, including acute alcoholism.
5. Asphyxia from disease, such as acute pulmonary conditions, asthma and cardiac decompensation.
6. Asphyxia from developmental and mechanical abnormalities, such as neonatal atelectasis and collapse of the lung.
7. Asphyxia from anesthesia due to overdosage, idiosyncrasy or a failure to meet mechanical obstruction, occurring in relaxation.
8. Asphyxia from submersion (drowning).
9. Asphyxia from flying at high altitudes.
10. Asphyxia from fire fighting (smoke, chemical poisoning)
11. Asphyxia from obstruction by foreign bodies.
  - (a) Material caught in the esophagus or inhaled.

(b) Tumors or infections within or without the airway.

12. Asphyxia from electrocution.
13. Asphyxia from strangulation.
14. Asphyxia from allergy.
15. Asphyxia from terminal poliomyelitis.

In an attempt to revise this list and to propose a group of causes of asphyxial death, generally acceptable to recognized authorities in pathology, toxicology, physiology, medical jurisprudence and internal medicine, a communication was directed to a group of twelve men, each distinguished in his particular field. Nine replies resulted, and six favored the listing submitted. One suggested "one other cause of asphyxiation, which is rare, but which might be included. There have been a few deaths from a peculiar form of polyneuritis with facial diplegia in which death has occurred from respiratory failure and asphyxiation."

One correspondent objected that in view of the definition of asphyxial death as that type of asphyxiation which when relieved by suitable means of resuscitation results in saving the life of the patient, and the generally accepted first treatment as artificial respiration, the wisdom of including numbers 14, 11 and 5 could be questioned. "No. 5, Asphyxia from Allergy, certainly should not be treated first with artificial respiration, but rather with intravenous or intracardiac injections of epinephrine solution. No. 11, Asphyxia from Obstruction by Foreign Bodies, in some cases should be treated by artificial respiration, in others this would be likely to do harm rather than good. Of the diseases grouped under No. 5 you would probably kill your patient doing the artificial respiration. No. 5 includes asthma, which also properly comes under No. 14."

It is the intention of our recommendations for the treatment of asphyxia to precede or accompany artificial respiration in each case with a definite attempt to remove the cause of asphyxiation.

In the case of foreign body obstruction, artificial respiration, per se, if practiced by exposure of the airway, removal of foreign matter, and in the extreme case, intubation and insufflation of oxygen, would dispose of the difficulty in the routine course of treatment.

In allergy, and in other conditions involving circulatory complications, it is the intention to accompany the treatment of acute asphyxia in which the airway is cleared and oxygen administered, by synchronous intravenous or intracardiac medication.

Three authorities answered the communication with diverging opinions. One stated:

"I would define asphyxia as a condition in which absorption of oxygen from the lungs is suddenly and dangerously impaired. It may be brought about by lack of oxygen in the respired air, by occlusion of the respiratory passages or alveoli, or by paralysis of the muscles of respiration. I find it difficult to define asphyxia in its relation to treatment. I would not be inclined to include deficient oxygenation associated with drugs, etc. (4); disease (5); anaesthesia, etc. (7); or allergy (14); unless in conformity with the definition above. For example, the diminution of lung substance by tuberculosis, even when extreme, does not, it seems to me, produce a condition properly designated as asphyxia, whereas, obviously, pulmonary hemorrhage may. I should not designate the condition of oxygen deficiency associated with cardiac decompensation as asphyxia. I do not understand exactly what is meant by asphyxia from allergy, unless it is associated with asthmatic attacks."

We have followed the definition of asphyxia as it appears in Stedman's Medical Dictionary. It is understood that the loss of function of the respiratory center enervating the respiratory mechanism is one of the important causes of asphyxia. Under this heading appears the action of various drugs which are respiratory depressants. From the point of view of the clinician, the immediate problem is oxygen want and the immediate

treatment is to supply this oxygen deficiency. Where oxygen is administered over a long period the effects of central depression from drugs may be overcome and the patient rescued. We see this situation in suicidal attempts with barbiturates, morphine, and other drugs as well as in idiosyncrasy to medication, preceding anesthesia. There is a record of a case in which 87 gr. of sodium amytal had been taken. Intratracheal insufflation of oxygen over a sufficient period carried the patient through his central depression. In circulatory abnormalities, if a period of oxygen want can be bridged over to recovery of the cardiovascular mechanism, the patient may be expected to survive.

As a result of the inquiry undertaken, the following list of the causes of asphyxia has been found generally acceptable to the advisory group to which it was referred.

1. Asphyxia Neonatorum.
2. Asphyxia from gases, used industrially.
  - (a) Carbon monoxide from illuminating gas and from engine exhaust, coke and coal fires.
  - (b) Refrigerants such as ammonia, carbon dioxide and dry ice.
  - (c) Fumes in the manufacture of chemicals.
  - (d) Gases associated with the oil industry.
  - (e) Gases in the mining industry.
  - (f) Fumigation for disease; the destruction of rodents on board ship and elsewhere.
3. Asphyxia from gases in warfare.
4. Asphyxia from drugs, hypnotics, narcotics, and sedatives including acute alcoholism.
5. Asphyxia from disease, such as acute pulmonary conditions, asthma and cardiac decompensation.
6. Asphyxia from developmental and mechanical abnormalities, such as neonatal atelectasis and collapse of the lung.
7. Asphyxia from anesthesia due to overdosage, idiosyncrasy or a fail-

ure to meet mechanical obstruction, occurring in relaxation.

8. Asphyxia from submersion (drowning).
9. Asphyxia from high altitude flying.
10. Asphyxia from fire fighting (smoke, chemical poisoning).
11. Asphyxia from obstruction by foreign bodies.
  - (a) Material caught in the esophagus or inhaled.
  - (b) Tumors or infections within or without the airway.
12. Asphyxia from electrocution.
13. Asphyxia from strangulation, garroting, hanging.
14. Asphyxia from allergy.
15. Asphyxia from terminal poliomyelitis.
16. Asphyxia from suffocation, overlying, suffocation with soft materials such as pillows, etc.
17. Asphyxia from external pressure on chest and abdomen as caught between two moving objects (automobiles, elevators, and laundry machinery).
18. Asphyxia from collapse of buildings, earth mounds, caves, sand, fire coal in large coal bins, land slides.
19. Asphyxia in manholes, wells, and declivities in the ground, usually from lack of oxygen and increase of CO<sub>2</sub> and sometimes poisonous gases.
20. Asphyxia from polyneuritis, with facial diplegia.

PALUEL J. FLAGG, M.D.

## CORRECTION

Dr. W. Wayne Babcock has called our attention to an unfortunate error in his article on "Experiences with Resection of the Colon and the Elimination of Colostomy" which appeared in the October issue of The American Journal of Surgery.

On page 188, where instructions are given for spinal anesthesia, the amount of pontocaine is incorrectly stated as 100 mg., rather than 10 mg. The larger amount would of course be highly dangerous for intradural injection.

# ORIGINAL ARTICLES

## WATER BALANCE\*

EARL O. LATIMER, M.D., F.A.C.S.

CHICAGO, ILLINOIS

THE maintenance of the body fluid level, both intracellular and extracellular, is termed water balance. In a normal person this is at a fairly constant level and is self-regulatory. The kidneys have more to do with the maintenance of the chemical concentration of the plasma,<sup>1</sup> and thus of the entire body fluid, than of the fluid level. Water balance is a complex problem. This paper will deal mainly with the two chief components—water metabolism and salt metabolism. Before abnormal states of water and salt metabolism can be discussed, an understanding of their rôle in health is necessary.

### WATER METABOLISM

In health water is ingested by mouth and absorbed from the gastrointestinal tract. It is lost by vaporization, urination and in the stool. As the body needs more water the sensation of thirst reminds one to take more fluid. The fluid absorbed from the gastrointestinal tract is distributed in the body to the blood plasma, to the cells and to the intercellular tissue. The sources of body fluid are (1) water ingested, (2) food ingested, and (3) oxidation of body material.

As expected, the greatest source of water is that taken by mouth, which normally varies from 800 to 3,000 c.c. daily, being greatest during warm weather. Under unusual circumstances the water intake may be greatly increased. Men working in the canyon, building the Boulder Dam, where the temperature was as high as 120°

Fahrenheit, drank as much as 10,000 to 18,000 c.c. of water daily. Men working about steel furnaces and in boiler rooms likewise drink huge quantities of water. In such instances the excessive salt loss must be replaced, a problem the industrial medical directors are solving.

The second and very important source of water is from food, since about 70 per cent of its weight is water. The average hospital maintenance diet yields 1,000 to 1,500 c.c. of water, while the soft diet yields about 500 c.c. of water.<sup>2</sup>

The third source of body water is from the oxidation of the body tissue. The oxidation of 1 Gm. of protein yields 0.4 Gm. of water, of 1 Gm. of carbohydrate 0.6 Gm. of water and of fat 1.07 Gm. of water. This source is responsible for from 200 to 400 c.c. of water daily and in starvation as much as 500 c.c. of water becomes available. The combined water content of solid food ingested and as a by-product of oxidation amounts to 0.9 Gm. of water for each gram of solid food eaten.

The loss of water from the body is from three sources, i.e., vaporization, urination and in the stool. The skin and lungs dissipate body heat by vaporization. This vaporization process is continuous in that there is always some vapor in the breath and on the body surface. Even without visible sweating 25 per cent of the body heat is dissipated by water of vaporization. This insensible loss of body fluid amounts to 1,000 to 1,500 c.c. daily.<sup>3-6</sup> The remaining 75 per cent of body heat is normally

\* From the Department of Surgery, Northwestern University Medical School and the Wesley Memorial Hospital.

dissipated by radiation, conduction and convection from the body surfaces. As visible sweating occurs, up to 100 per cent dissipation of body heat may take place by vaporization.

It is an interesting and important fact that vaporization is little affected by the amount of water available. Thus vaporization has priority over the kidneys on water available.

The kidneys, on the other hand, are markedly affected by the amount of water available. They excrete the waste material presented to them in water left after other processes have been cared for. Thus, there may be a large daily output of urine of a low specific gravity or vice versa. Especially in disease there is apt to be a deficiency in urine with a retention of some of the waste material in the blood stream with a resulting rise in the plasma non-protein nitrogen. In general, an adequate output of urine is indicative of an adequate fluid intake—i.e., *water balance*. However, as will be discussed later, this does not mean a proper salt metabolism. A small urine volume of high specific gravity usually means insufficient water intake, while excessive quantity of urine of a low specific gravity is indicative of the taking of excessive amounts of water.

TABLE I

Kidneys	Maximum Concentrating Ability, Specific Gravity	Minimum Amount of Water Required to Excrete 35 Gm. of Waste Materials, c.c.
Normal.....	1.032-1.029	473
Diseased.....	1.028-1.025	595
	1.024-1.020	605
	1.019-1.015	850
	1.014-1.010	1,439

As an arbitrary standard 35 Gm. of waste material that must be excreted by the kidneys daily may be accepted for an average adult. Lashmet and Newburgh<sup>7</sup> determined the excretory capacity of the

kidneys in health and disease. Table 1 (from Maddock and Coller,<sup>5</sup> based on Lashmet's and Newburgh's<sup>7</sup> work) indicates the minimum amount of urine of various specific gravities that must be excreted to remove 35 Gm. of waste material.

Persons with normal kidneys require a urinary output of only 500 c.c. if they concentrate to maximum capacity, while severely damaged kidneys with low concentrating capacity 1.010-1.014 require nearly 1,500 c.c. of urine to excrete the same amount of solids. The excretion of smaller quantities of urine for given concentrations will result in retention of waste materials and an elevation of the non-protein nitrogen of the blood.

In disease it is safer to assume that the kidneys have only a low concentrating ability and to strive for a minimum output of 1,500 c.c. of urine daily. While some believe 750 to 800 c.c. daily output of urine is adequate, if such quantities are accepted then frequent specific gravities of the urine should be determined and these should be 1.020 or above. Thus the hydration or dehydration of the patient is easily checked by determining the urinary output if the salt metabolism is normal. At the same time this daily observation will indicate whether enough solids are being removed.

Water lost in the normal stool is negligible. Since the function of the colon is to dehydrate the bowel content, an average of only 150 c.c. of water is lost daily by this route. This is interesting since from 7,000 to 10,000 c.c. of fluid are poured into the upper gastrointestinal tract daily. Obviously in cases of diarrhea the fluid loss by means of the stools may become alarming.

#### SALT (SODIUM CHLORIDE) METABOLISM

Water balance cannot be divorced from sodium chloride metabolism because the loss of this electrolyte is dependent on water to carry it away in solution. The normal daily salt requirement as given

by different authorities varies from 1 to 10 Gm.<sup>8-11</sup> We may compromise on 4.5 Gm. as the average daily requirement. This salt intake must be greatly increased in normal people working under abnormal conditions where there is excessive salt loss, as in stokers and steel furnace workers, etc.

Sherman<sup>9</sup> has estimated the total salt content of the body as 0.15 per cent of the body weight expressed as chlorides or 0.248 per cent of the body weight expressed as sodium chloride. The total sodium chloride content of a 60 kg. person would be 148.8 Gm.

Sodium chloride has two main body functions. As an electrolyte it aids in maintaining the acid-base balance of the body by its sodium and chloride ions. The other function is to aid in the distribution of body fluids and the regulation of their amounts by its influence on osmotic pressure.

In the role of acid-base balance, if the chloride ion is lost as in high intestinal obstruction, it is readily replaced by the bicarbonate ion.<sup>10</sup> Most significant is the fact that when the sodium ion is lost no other ion can adequately take its place. Therefore, in the loss of excessive amounts of sodium ion without the loss of chloride ion, chloride and bicarbonate ions are excreted in order to maintain the body acid-base balance. This results in a definite depletion of the total electrolyte content which in turn leads to a decrease of the total body water, or dehydration. Dehydration subsequent to loss of gastrointestinal secretion is due to the loss of sodium ions.

Salt balance in a healthy individual is of no practical significance. The chloride content of the blood expressed as sodium chloride (since pure chloride determination is not feasible) is 450 to 500 mg. per 100 c.c. of blood. Or if expressed as plasma sodium chloride, it is 550 to 630 mg. per cent. This blood chloride content in health does not change even if huge quantities of salt are ingested. The average person

ingests daily from 8 to 12 Gm. of salt. About 2 per cent or 0.2 Gm. is excreted in the feces, 0.24 to 0.41 Gm. is lost through the skin in absence of sweating. Only 0.5 Gm. is normally lost through these channels, and the balance, after being used for body requirements, is excreted in the urine. The urine may contain up to 2 per cent salt. In cases of diarrhea, gastrointestinal loss, sweating, etc., the urine chlorides are decreased. The calculated body requirement varies from 1 Gm. daily<sup>8</sup> to 5 to 10 Gm.<sup>11</sup>

Excessive amounts of salt when ingested are removed in the urine or may cause diarrhea. The picture is different in disease<sup>6</sup> and the excessive sodium chloride is retained along with water, resulting in edema. This causes a hydremia and not a hyperchloremia.

A different situation occurs in cases of inadequate salt intake. When the salt ingested is below body requirements normal quantities of chlorides will be excreted in the urine for a few days then be reduced, but small amounts of chlorides will be excreted each day. A man fasting thirty-nine days excreted 20.3 Gm. of sodium chloride during this time, of which 50 per cent was lost in the first four days.<sup>12</sup> After several days of fasting the kidneys conserve salt by excreting less than 0.5 Gm. per day and if salt is lost elsewhere, as in an intestinal fistula, the urinary output falls below 0.1 Gm. per day.

Investigators have found that the loss of chlorides through normal and abnormal body fluid losses causes first a fall in the blood chlorides—hypochloremia—and second a depletion of the body chlorides in general. This is often followed by an alteration in the acid-base balance, and commonly there is an increase in the blood non-protein nitrogen as a later manifestation.<sup>11</sup>

If, instead of a loss of both the sodium and the chloride ions, there is a loss of one in excess over the other, then different blood findings occur. In the case of a loss of chloride ions—for example, in long

continued gastric aspiration—the chloride ion loss is compensated by an increase of the bicarbonate ion. Thus the water balance of the body is maintained if enough water is available. However, the reduced chloride content of the blood causes an alkalosis with an increased carbon dioxide combining power. In the absence of a sufficient amount of water the urinary output is reduced and the blood non-protein nitrogen is increased. If enough water is then supplied the total non-protein nitrogen falls, but not the carbon dioxide combining power of the blood.

The body has no substitute for the excessive loss of the sodium ion, and acidosis results, with a lowered blood carbon dioxide combining power. Body fluids are lost in excess and an increase in the blood non-protein nitrogen occurs. Giving water alone will not improve the dehydration but may even make it more severe. Only the replacement of the sodium ion will correct the condition.

The third possibility—equal loss of sodium and chloride ions—will not change the acid-base relationship, but dehydration will occur. Dehydration occurs in the body's effort to maintain the sodium concentration and the osmotic pressure at a constant level. If the salt loss and its accompanying water loss continue, eventually it is more important for the body to retain water than to maintain a constant sodium chloride level and then the blood chlorides fall. Bartlett<sup>11</sup> and his co-workers believe that the non-electrolyte urea is retained to maintain the osmotic pressure. The blood non-protein nitrogen is increased and the mere administration of water will not lower it significantly; salt is also necessary.

#### DEHYDRATION

Our first consideration is dehydration attendant on surgical operations. About 70 per cent of the fluid loss during an operation is due to vaporization. The remainder is due to blood loss, vomitus

and urine secreted. The urinary secretion is small. Surgeons working on the pelvic organs for sixty to ninety minutes, or more, are not disturbed by the urinary bladder becoming filled. Preoperative dehydration of the patient can be avoided to a great extent by substituting parenteral administration of fluids if fluids cannot be taken freely by mouth.

In the operating room the loss through perspiration can be reduced greatly by using light drapes. Air conditioned and humidity controlled operating rooms are a great aid in this direction. The old "ether bed" added insult to injury by further sweating and dehydrating an already partially dehydrated patient. Except in cases of shock a comfortable bed with light covers is all that is needed.

The blood lost during surgical procedures is a factor in dehydration, depending upon the amount of blood lost. The figures in Table II were accurately determined for eleven cases.<sup>5</sup> The figures for the brain surgery represent the extremes of several cases.<sup>13</sup>

TABLE II  
BLOOD LOSS DURING TYPICAL OPERATIONS

Operation	C.C. of Blood Lost
Partial gastric resection.....	274
Excision of thyroglossal cyst.....	174
Repair of inguinal hernia.....	54 and 147
Hemorrhoidectomy.....	8
Appendectomy.....	14
Excision retroperitoneal teratoma.....	546
Radical Mastectomy.....	1,272
Thyroidectomy.....	142 and 361
Repair of ventral hernia.....	306
Brain operations (White, Sweet and Hurwitt).....	22 to 2,050

It is evident that the routine procedure of administering fluids either by hypodermoclysis or intravenously during the course of the operation is on a sound basis. In calculating the amount of fluids to be administered on the operative day it is wise to allow for 500 to 1,000 c.c. excessive loss during the course of the operation and immediately following. A custom I practice is to ignore the fluids given in the operating room in calculating the daily volume

of fluids to be given but not the salt given. Thus, if it is determined that the patient should receive 3,500 c.c. of fluid, this is given in addition to the fluids given in the operating room. However, if 1,000 c.c. of physiologic salt solution is given during the operation, while for the day 4,500 c.c. of fluid should be given, ordinarily the remaining 3,500 c.c. would be given as 5 per cent glucose in distilled water. The rôle of such fluids in preventing or lessening the degree of surgical shock also commends their use during the surgical procedure.

*Postoperative Loss of Fluid.* A smoothly convalescing patient will vaporize the same amount of fluid as will a normal person—1,000 to 1,500 c.c. in twenty-four hours. The presence of a fever will increase the amount of water lost by vaporization to as much as 2,500 c.c. A hyperthyroid state is characterized, among other things, by a warm moist skin and the water of vaporization is frequently 1,500 to 2,000 c.c. It must be remembered that this water of vaporization is lost before fluid is available to the kidneys.

Abnormal fluid losses may be great and if ignored will upset the water balance. Such abnormal losses may be from hemorrhage, vomitus or fluid aspirated from the upper gastrointestinal tract, diarrhea, biliary or intestinal fistula and excessive expectoration.

These fluid losses may be preoperative, postoperative or both. It is not uncommon to aspirate 500 to 1,000 c.c. or more of fluid from the stomach and duodenum when the indwelling catheter with negative pressure is used. In case of a biliary fistula similar amounts may be lost.<sup>8</sup> Severe diarrhea may cause enormous loss of fluids as well as of sodium ions. Excessive expectoration is rarely a cause of sufficient fluid loss to necessitate replacement. Large denuded areas may cause considerable fluid loss but usually the protein loss is more important.

We are now in a position to calculate the necessary water intake in order to maintain the water balance of the patient.

(Table III.) It will be shown that such fluid must be properly balanced as to total salt content.

TABLE III  
WATER NEEDED FOR EXCRETION PER 24 HOURS<sup>5</sup>  
C.c.

1. Insensible water loss.....	1,500 to 2,000
2. Urine.....	1,500
3. Abnormal loss (vomitus, etc.).....	
	3,000 to 3,500

An average adult patient with no abnormal water loss requires a daily intake of approximately 3,500 c.c. of fluid. Where there is an abnormal water loss this should be quantitatively determined and an equal volume of water added to the fluid intake. If an indwelling catheter is in the stomach or duodenum and fluids are given by mouth, this quantity must be deducted from the total aspirated volume to arrive at a correct figure for the gastric-duodenal material aspirated.

To calculate the total water intake required to maintain the water balance in an adult with constant aspiration of the stomach and with the patient being permitted to drink water, it is necessary to add the net aspirated stomach contents to the basic requirements of 3,500 c.c. Thus, if 1,250 c.c. of material is aspirated from the stomach in twenty-four hours, but 750 c.c. of water has been drunk, then there is a net aspirated stomach content of 500 c.c. The patient should then receive 3,500 c.c. plus 500 c.c. or 4,000 c.c. of fluid in that twenty-four hours.

With many patients subjected to continued stomach aspiration preoperatively, it is well to remember that they may come to the operating room in a state of partial dehydration and even hypochloremia unless this fluid and electrolyte loss is replaced.

A rule worth repeating is that in general the simplest test of hydration of the patient is to measure the twenty-four hour urinary output. This should be 1,500 c.c.



### WATER BALANCE OF THE DEHYDRATED PATIENT

If a patient is dehydrated before presenting himself for treatment or if he is permitted to become dehydrated, additional problems arise. The symptoms of dehydration are dry hot skin, parched tongue, slight fever, sunken eyes, scanty urine of high specific gravity. There may be albumin in the urine in the severe cases and the blood non-protein nitrogen is increased to as high as 40 mg. per 100 c.c.

When serious dehydration occurs, the water loss may amount to 6 per cent of the body weight.<sup>5</sup> A loss of about 10 per cent is incompatible with life. Table IV gives the amount of water equal to 6 per cent for various body weights.<sup>5</sup>

TABLE IV

Body Weight	6 Per Cent, C.c.
10 Kg. or 22 pounds.....	600
20 Kg. or 44 pounds.....	1,200
60 Kg. or 132 pounds.....	3,600
80 Kg. or 176 pounds.....	4,800

If a 176 pound patient is dehydrated he would theoretically need in the first twenty-four hours 4,800 c.c. plus 3,500 c.c., or 8,300 c.c. of fluid. A blood chloride determination is necessary to determine how much sodium chloride need be given (the method of calculation for this will be given later). Some workers prefer to hydrate such a patient over two or more days.

### SIGNS AND SYMPTOMS OF HYPOCHLOREMIA

It is interesting that at times we attribute certain symptoms to the disease rather than to the reduced blood chlorides. The *symptoms* of hypochloremia are as follows:<sup>11</sup>

Group A: 1. Marked lethargy

2. Lassitude
3. Depression
4. Weakness
5. Fatigue

Group B: 1. Dulling sense of taste

2. Anorexia
3. Nausea

Group C: 1. Dulling of mentality

2. Drowsiness
3. Stupor
4. Coma

Group D: 1. Muscular twitching

2. Cramps

The less constant signs of hypochloremia are:

1. Dehydration—signs of which were listed before.
2. Alkalosis, with shallow slow respiration, and occasionally, tetany.
3. Acidosis may be present with deep rapid breathing.
4. Low pulse pressure may be present.
5. Shock.

Symptoms usually occur when the blood chlorides are 370 or below, but may occur at a much higher level. The diagnosis rests on the finding of low blood chlorides. Frequent blood chloride estimates are expensive and often impractical. In such cases the urinary excretion of sodium chloride can be determined. A roughly quantitative determination can be quickly made by the method suggested by Fantus.<sup>14</sup> The method is as follows: "Place 10 drops of urine in a test tube. Add one drop of a 1 to 5 potassium chromate solution. The fluid will now assume a distinctly yellow color. Add drop by drop, with the same dropper or one of the same caliber, a 2.9 per cent silver nitrate solution until a permanent and distinct color change to red-brown occurs (silver chromate). The number of drops required to produce the change of color expresses in grams the content of chloride per liter of urine." Fantus<sup>14</sup> believes that, except in emergencies, no patient should be sent to the operating room unless he has passed at least 1,500 c.c. of urine in the preceding twenty-four hours and unless this urine contains at least 0.5 per cent of chloride. Dehydrated patients with hypochloremia would not be operated on.

To prevent hypochloremia in surgical patients who cannot take fluids by mouth it is necessary to give a minimum of 500 c.c. of physiologic salt solution which

contains approximately 4.5 Gm. of sodium chloride. Unless contraindicated because of kidney damage we give 1,000 c.c. of physiologic salt or Ringer's solution. The abnormal fluid loss is replaced volume for volume with physiologic salt solution or Ringer's solution. This 1,000 c.c. of solution that is given routinely contains twice the normal daily requirement of sodium chloride and will compensate for the first 500 c.c. of abnormal fluid loss. In determining the gastric secretion, the amount of water drunk is deducted from the total aspirated volume to get the true amount of gastric fluid lost. The balance of the water must be given without the electrolyte.

If the patient has developed hypochloremia we are confronted with the problem of supplying enough sodium chloride to bring the blood chlorides up to normal. Orr<sup>15</sup> has suggested giving to such patients 250 to 500 c.c. of a 2.5 to 5 per cent solution of sodium chloride intravenously. This method will work but it is empirical, not based on a quantitative need, and the solution is definitely hypertonic. Bartlett<sup>11</sup> and his co-workers have evolved a formula based on the absolute requirement of salt of a patient of any weight. This formula makes use of Sherman's<sup>9</sup> determination of the normal body content of salt being 0.248 per cent of the body weight. The formula is:

$$\text{Gm.* salt needed} = \frac{450 - \text{actual blood chlorides}}{450} \times 2.48 \times \text{kg. of body weight.}$$

From this formula a clinical rule simple in its application was formulated: For each 100 mg. that the whole blood chlorides need to be raised to reach the normal (450 mg.) the patient should be given

\* If chloride estimates are for plasma chlorides rather than blood chlorides, then the formula would be:

$$\text{Gm. salt needed} = \frac{560 - \text{actual plasma chlorides}}{560} \times 2.48 \times \text{kg. body weight.}$$

0.6 Gm. of sodium chloride per kg. or 0.25 Gm. per pound of body weight.†

In these determinations the lower normal level is used since it is not possible in many patients to elevate the blood chlorides above the lower limits of normal. If desired, the calculations may be made on higher values for normal.

According to the clinical rule, a 60 kg. person with a blood chloride of 350 mg. per cent requires 36 Gm. of salt to raise the blood chloride to a normal of 450.

$$\frac{100 \text{ mg. needed to raise to normal}}{100}$$

$$\times 0.6 \times 60.0 = 36.0$$

If the exact formula were used instead of the clinical rule, it would be found that 33.0 Gm. of salt were needed. This discrepancy is insignificant clinically.

If only the dehydrated weight of the patient is known, the hydrated weight can be calculated as follows:

$$\text{Hydrated weight} = \frac{\text{Dehydrated weight}}{0.94}$$

The salt should be replaced as an isotonic solution, either physiologic salt or Ringer's solution. If physiologic salt is used the patient should receive

$$\frac{36.0}{8.5} = 4.2 \text{ liters.}$$

When it is not possible accurately to measure the abnormal body losses, management is difficult as too little or too much salt may be administered with a hypochloremia persisting in the former and edema occurring in the latter. Frequent blood chloride determinations may be made but the simpler and more rapid urine chloride determination of Fantus<sup>14</sup> is usually sufficient. While excessive salt secretion in the urine is usually indicative of excessive salt intake in disease, this is

† If plasma chlorides rather than blood chlorides are determined, the rule is: For each 100 mg. that the plasma chloride level needs to be raised to reach the normal, the patient should be given 0.5 Gm. per kg. or 0.2 Gm. per pound of body weight.

not necessarily true nor does the blood chloride content go above normal.

Certain complicating factors should be mentioned; the ideal management of these problems is still unsolved. In cases of edema, ascites, and hydrothorax a vicious circle often develops.<sup>16,17</sup> In an attempt to maintain the osmotic pressure of the transudate the blood chlorides are depleted. If large amounts of sodium chloride are given more fluid is retained.

#### METHODS OF ADMINISTRATION OF FLUID

1. By mouth (most desirable where feasible)
2. Proctoclysis
3. Retention enema
4. Subcutaneously
5. Intravenously

Needless to say, the patient able to take fluids by mouth and absorb the fluid from the gastrointestinal tract should receive fluids orally.

Proctoclysis or retention enemas of tap water or physiologic salt solution are the second most simple method of administration of fluids. However, there is a limit to the amount of fluid that can be absorbed from the colon. Such administration is distressing to many patients and should be reserved in certain cases for the administration of drugs, when the patient is unable to take drugs by mouth. Rectal administration of fluids and drugs is too often overlooked. Glucose, however, is not absorbed from the rectum.<sup>18</sup> McNealy<sup>19</sup> believes there is an advantage in administering by rectum the aspirated stomach and duodenal contents except in patients with carcinoma of the stomach.

The administration of fluids by hypodermoclysis is not a dangerous but too often a painful procedure. The needles should not be introduced near large vessels or nerves, nor should the fluid be introduced too near the joints. The axilla is the ideal location for the introduction of subcutaneous fluids because of the large amount of loose areolar tissue and the wealth of lymphatics. Probably the poorest

location for hypodermoclysis needles is in or beneath the breasts. The widespread use of the breasts for such fluid administration has done more than any other single factor to bring a most valuable procedure into disrepute, especially in the estimation of the patient.

The use of large quantities of fluids subcutaneously calls for various sites for their introduction. The thighs offer a convenient location. The outer surface of the thigh is preferable to the inner side, although more painful, and absorption is less rapid. The inner aspect of the thigh is undesirable because of the universal contamination of this area and the frequent incidence of varicose veins. Fluids introduced about old varicose veins may cause an exacerbation of an old thrombophlebitis. Practically all sloughing of tissue secondary to hypodermoclysis occurs on the inner aspect of the thigh. An excellent practice in giving fluids by hypodermoclysis is to give 1 liter, remove the needles and, several hours later, reinsert the needles, giving a second liter. This procedure should be repeated until the desired quantity of fluid is administered. Isotonic glucose solution is more slowly absorbed from the subcutaneous tissues than is physiologic salt solution.

With the many refinements in the preparation of fluids, intravenous administration is the method of choice with many clinicians. It has the advantage of being less painful than hypodermoclysis. Chills and fever are rare occurrences following phleboclysis today, and if such do occur, the preparation of the rubber tubing should be carefully checked before blaming the accepted commercial preparations for intravenous administration. Occasionally such fluids are apparently at fault. Each flask should be carefully inspected for any change in color or gross foreign particles before administering it. The hazards of intravenous administration are avoidable by the exercise of reasonable care and skill. (1) The circulatory system may be overburdened by too rapid increase in the blood volume. The rate of flow of

intravenous fluids should be 250 to 500 c.c. per hour. In heart damage a lower figure is preferable. (2) General edema and edema of the lungs are secondary to overburdening the heart. (3) Thrombosis of the vein at the site of injection is easily avoided by removing the needle after completing the injection and frequently changing the veins chosen for injection. Varicose veins should be avoided as the site of injection because of the danger of lighting up a dormant thrombophlebitis, a serious complication in any illness. (4) Increase of the degree of dehydration of the patient by the use of hypertonic solution<sup>20</sup> is to be avoided. (5) Hassin<sup>21</sup> recently reported eight cases of nerve injuries subsequent to administration of fluids in the basilic and cephalic veins at the bend of the elbow. Care in introduction of the needle into the vein and avoiding spilling fluid outside of the vein will prevent such accidents. Veins on the dorsum of the hand are often useful for introduction of fluids.

#### FLUIDS THAT MAY BE ADMINISTERED

Water is the simplest fluid that may be administered by mouth and is the vehicle of all solutions taken into the body. As long as water can be given orally in adequate amounts we need not worry about other methods of administration. If necessary, sodium chloride or glucose may be added to the fluid given orally. Tap water or physiologic salt solution may be given by rectum. Too much water may be given, with a resulting water intoxication. Helwig<sup>22,23</sup> and his associates reported two cases of water intoxication associated with a lowering of the blood chlorides. One patient died and one recovered. The patient who recovered received 7,000 c.c. of tap water by proctoclysis in the first thirty-six hours after operation. At this stage the patient became unconscious and developed convulsive movements. The blood chlorides fell to 380 mg. per cent. Recovery followed administration of hypertonic sodium chloride solution and sodium chloride by

mouth. There was an edema of the cerebral tissue in the patient who died.

It has been found<sup>24</sup> that approximately 70 per cent of the body consists of water which moves between intracellular and extracellular tissues to maintain an osmotic equilibrium between the intracellular and extracellular fluids. Sodium ions and chloride ions are the chief electrolytes of the extracellular fluids. Intracellular electrolytes are believed to be proteins, potassium and phosphates. Thus, as the salt is removed from the extracellular fluid, water passes into the cell to readjust the osmotic pressure with the extracellular fluid. As a result there is an edema and swelling of the cell, thus explaining the edema of the cerebral tissue in Helwig's fatal case of water intoxication.

**Salt Solutions.** Physiologic salt solution, Ringer's solution and Hartman's solution may all be considered under the classification of salt solutions. Physiologic salt solution is 0.85 per cent salt in distilled water. Ringer's solution contains slightly less sodium chloride, but in addition has calcium and potassium ions. In Hartman's solution there is sodium lactate as well as the constituents of Ringer's solution.

Physiologic salt solution is isotonic. If less than 0.85 per cent salt is contained in the solution, solution should be made isotonic by the addition of glucose.

Since physiologic saline solution contains 8.5 Gm. of sodium chloride per liter, a patient who receives 3,500 c.c. of such solution receives approximately 30 Gm. of sodium chloride or seven times the average daily requirement of 4.5 Gm. Samson-Wright<sup>7</sup> states that isotonic salt or similar solutions which are drunk are retained better than if given intravenously. Maddock and Coller<sup>5</sup> found that patients given 5 per cent glucose in physiologic salt or Ringer's solution retained water, less being retained if Ringer's solution was used. The work of Maddock and Coller demonstrated that salt metabolism in disease is not the same as in health and that

excessive quantities of salt in solution cause retention of water in the tissues. These workers found that patients receiving 5 per cent glucose in distilled water did not retain water in the tissues.

*Glucose.* A 5 per cent solution of glucose in distilled water is isotonic. This is our best method of giving water parenterally without the introduction of an electrolyte to upset the water balance. The water exchange when isotonic glucose solution is given is the same as if the fluids were given by mouth. Thus a patient requiring 3,500 c.c. of water in twenty-four hours would best receive this as 1,000 c.c. physiologic salt solution or Ringer's solution and 2,500 c.c. as 5 per cent glucose in distilled water.

Animals will tolerate up to 0.8 Gm. of glucose per kg. of body weight per hour when given intravenously without any trace of it in the urine.<sup>8,25</sup> When 0.9 to 2 Gm. of glucose per kg. of body weight are administered intravenously per hour some of the excess is eliminated in the urine. Translated into working terms, a 175 pound (80 kg.) man should tolerate up to 1,280 c.c. of 5 per cent glucose per hour or 640 c.c. of 10 per cent glucose per hour. Clinically it is found that when 5 per cent glucose is given at the rate of 300 to 500 c.c. per hour, 79 per cent of the patients will exhibit sugar in the urine and if 10 per cent glucose is given at the same rate, all will present sugar in the urine.<sup>26</sup> This may occur without an elevation of the blood sugar and the amount of sugar spilled is insignificant. In diabetics, as well as in non-diabetics, the sugar may be "covered" when desired by an adequate dose of insulin. More urine is secreted if 10 per cent glucose solution is given intravenously than if 5 per cent glucose is administered.

While an isotonic solution is physiologically sound there are occasions when hypertonic solutions are justifiable, but such cases are exceptions and not the rule. In patients with hyperthyroidism or liver damage 10 per cent glucose in distilled

water is often the solution of choice. There are 200 calories per liter of 5 per cent glucose and 400 calories per liter of 10 per cent glucose solution, so where extra calories are needed 10 per cent glucose solution may be preferred.

*Salt and Glucose Mixtures.* It is in the use of mixtures or combinations of salt and glucose that we find the greatest number straying from physiologic principles. It is a practice of almost all commercial houses to prepare 5 per cent glucose in physiologic salt, Ringer's, or Hartman's solutions. In fact, many hospitals do not stock glucose in distilled water. Thus the first violation of physiology is to give every patient receiving such combination a hypertonic solution. While there is a large factor of safety, it is not necessarily always safe—if so, there is no reason for insisting on the salt solution, Ringer's and Hartman's solutions being isotonic.

Secondly, such combinations of salt and glucose lead to the intake of unnecessarily large quantities of salt, which cannot be removed by the sick patient and lead to edema. This error is due frequently to the assumption by the clinician that the glucose is dissolved in distilled water.

If it is desired to give a combination of salt and glucose, isotonic solutions of 0.425 per cent sodium chloride and 2.5 per cent glucose or variations of these constituents to maintain an isotonic solution should be given.

Blood transfusions and gum acacia solution should be reserved for shock, hemorrhage, severe anemia, and edema from protein loss. While there are recorded instances of protein shock and death from the use of gum acacia, many still consider it a valuable adjunct for maintaining the viscosity of the blood.

#### SUMMARY

1. Water metabolism and salt metabolism are the chief factors in water balance.
2. No water is available to the kidneys until the requirements of vaporization are satisfied.

3. Normal kidneys need a urinary output of only 500 c.c. if they concentrate to maximum capacity, while severely damaged kidneys with low concentrating capacity (1.010–1.014) require nearly 1,500 c.c. of urine to excrete the same amount of solids.

4. The average daily sodium chloride requirement of an adult is about 4.5 Gm.

5. The loss of the chloride ion causes an alkalosis. The loss of the sodium ion causes an acidosis.

6. The parenteral administration of fluids during the course of operations is a rational procedure. Such fluid should not be considered in calculating daily volume of fluid to be given but the salt content should be considered.

7. A simple test of hydration is to measure the twenty-four hour urinary output, which should be approximately 1,500 c.c.

8. In case of serious dehydration the water loss amounts to 6 per cent of the body weight.

9. The clinical rule of Bartlett for determining the amount of sodium chloride required to bring the blood chlorides to normal in cases of hypochloremia is satisfactory.

10. The indiscriminate use of hypotonic and hypertonic solutions is to be condemned. The routine use of 5 per cent glucose in physiologic salt solution is not physiologic in principle.

11. The average patient unable to take fluids by mouth should receive 500 to 1,000 c.c. of physiologic salt solution. The balance of the water requirement should be given as 5 per cent glucose in distilled water.

12. Patients with hyperthyroidism and liver damage may be given 10 per cent glucose in distilled water.

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# THE EBB AND FLOW OF DEATH

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LIFE does not move in the channels of old, and death patterns have accordingly changed. Montaigne remarked "Men do not usually die; they kill themselves." The degree to which changes have occurred in the causes of death, raises a question as to the validity of the statement of the philosopher.

Selwyn D. Collins<sup>1</sup> recently indicated the prevalence of particular forms of ailments at specific age levels. He directed attention to the fact that the major causes of death are not necessarily the most frequent causes of illness and hence, "The respiratory diseases are outstanding as causes of illness whether non-disabling or disabling; the degenerative diseases are more important as causes of death." He demonstrated, however, that these respiratory diseases constitute an overwhelming part of the sickness burden at every age and that the existence of digestive disorders is important throughout life. In the light of his statement it becomes important to make a somewhat thorough investigation of mortality, as it is recorded at varying age levels.

Death, as a frustration of personal continuity, obviously is a somatic reaction to environment in terms of constitutional alterations in vitality. The marked change in the modern expectation of life and the advancement of survival values, along with changing morbidity rates, represents, to a large extent, the modification of environmental conditions rather than any specific advance in constitutional capacities. Thus, if the aeroplane brings about an increasing fatality rate, there is necessarily a shift in rates for other accidents and diseases. With the decline of tuberculosis because of the alteration and control of environmental factors, there is an increased possibility for

death to occur during the period of industrial activity from causes non-tuberculous in character. Similarly, it is obvious that with an increased recourse to surgery there is an additional possibility for an increased number of deaths following some ailments, operable or nonoperable, at an age earlier than such deaths might have occurred if no operation were performed. It is equally true that surgery has postponed many deaths to an age far beyond expectation. It is obvious that a considerable amount of shift in mortality rate is incidental to a very simple alteration in the environment. Insofar as infant mortality diminished under social attack, survival values to age 5 and above increased, as a result of which there were modifications of resistances which actually affected physical well being and altered, therefore, the percentile appearance of deaths from specific causes during the age 5 to 9 period. The development of first aid appliances, safety first teams, factory inspection and the like lowered mortality rates during the age period of industrial activity and thus enabled a larger group to advance into middle life and to die from causes especially lethal during the fifth and sixth decades.

Man's efforts to modify and better his environment have been constant during the ages but the advances of the past fifty years have been sharply precipitated by his scientific development. The Progress in Public Health charts, published in 1934 by the Metropolitan Life Insurance Company, reveal a remarkable contrast between the order of significance of the causes of death for 1900 and 1932. The following rates apply to the ten original states in the Death Registration Area and in the District of Columbia.

1900	Rate	1932	Rate
1. Tuberculosis....	195	Diseases of the heart	280
2. Pneumonia.....	176	Cancer.....	123
3. Diarrhea and enteritis.....	140	Nephritis.....	90
4. Diseases of the heart.....	137	Pneumonia.....	82
5. Nephritis.....	89	Cerebral hemorrhage.....	82
6. Congenital malformations and diseases of early infancy.....	88	Accidents.....	70
7. Cerebral hemorrhage.....	77	Tuberculosis.....	59
8. Measles, scarlet fever, pertussis and diphtheria..	76	Congenital malformations and diseases of early infancy.....	52
9. Accidents.....	72	Diabetes.....	28
10. Cancer.....	64	Suicide.....	19

It is notable that the total deaths from accidents had jumped from ninth place to the sixth place, while pneumonia fell from the second to the fourth place. Heart disease and cancer have risen to their higher positions because of many factors caught up in the changing age of our population, namely, the fact that a larger proportion now live to age 60, while there is a decreasing group of the population below age 25. One observes this definite rise in some causes of death incidental to the aging population levels and a falling off of other conditions once incidental to the earlier age period. If one notes the differences between the mortality rates for the two dates, one appreciates these distinctions very clearly. Thus, the rate of heart disease is more than doubled; cancer has almost doubled; nephritis is practically stationary but has risen in position; pneumonia has been reduced by half. One senses, therefore, shifts in values in terms of increasing, decreasing and stationary rates, which are not wholly caught up in the disease processes, per se, but are related to all the population changes in the general environment.

Sir Humphrey Rolleston<sup>2</sup> has suggested that the character of diseases such as scarlet fever, smallpox and typhus, has markedly changed and that this fact has

been responsible for the modification of their fatality rates. He emphasizes, however, that environmental changes are as significant as those incidental to the biologic modifications of etiologic factors. People have changed in their internal environment as well as in their external environment; and the differential values of food, poverty, the stress and strain of life, are matters of biologic as well as of sociologic import. No one can deny that war altered the incidence of disease, increasing trench mouth, for example, while it diminished obesity; allowing an increase of rickets in the general population, and a decrease of venereal disease along at least one military sector. There can be no doubt that in an industrial age, electrification and motorization have heightened the speed of life, augmented the wear and tear of individuals, and produced a profound effect upon blood pressure, cardiovascular-renal reactions, and the activities of the sympathetic nervous system. One would expect, therefore, the evident increased fatality rate from diseases of the circulatory and renal systems as well as the manifest rise in the mortality from diabetes and conditions secondary to arteriosclerosis.

It is obvious that fatalities must be altered as the result of human accomplishment. A group in the community who might have died from the now obsolescent typhoid fever, cholera, typhus, gastro-entero-colitis, relapsing fever and malaria, now must die from some other ailment during the same relative age period, or succumb to some other disease at a later age. It is also quite apparent that many diseases appear to have had their natural history altered; thus, syphilis appears to be less malignant; acute rheumatism and gout are rarer; cirrhosis of the liver seemingly has declined; chlorosis has practically disappeared. On the other hand, numerous other diseases have been conditioned into existence, especially the large group known as occupational diseases, whether made manifest in the form of dermatitis, neuroses or psychoses.



Not alone have diseases undergone transformation, but one is able to note to a considerable degree the varying effects that they have had at different age levels. It is difficult to secure long range figures in the United States, but fortunately a few figures of Boston give some slight but impressive information concerning the average death rates from 1830 to 1930.<sup>3</sup> (Table 1.)

TABLE 1  
AVERAGE DEATH RATES IN BOSTON 1830-1930

Age Period	Average Death Rate	
	1826-1835	1929-1931
All ages.....	21.3	14.4
Under 5 years.....	64.8	25.6
5-9 years.....	8.5	3.1
20-29 years.....	10.7	3.9
40-49 years.....	22.7	10.7
70-79 years.....	91.2	93.6

The death rate dropped approximately one third at all ages, and one notes especially the fall of more than 50 per cent under age 5, and at 40 to 49 years approximately 63 per cent, with a tendency to increase only above age 70. It is impossible to compare the causes of death of these two periods because of the differences in nomenclature and the altered adequacy of diagnosis incidental to advances in medical knowledge, including, of course, a greater familiarity with microscopic techniques.

Topographic variations in death rates are notable with the lower rate in the Mississippi Valley south from the Dakotas, and the higher mortality rates on the Eastern coast with its industrial centers. There are also differences due to population characteristics of age, sex, marital status, prevalent nationalities, economic forces and recency of settlement, etc., which enter into all tables of mortality.

Farr has stated: "There is relation betwixt death and sickness; and to every death from every cause, there is an average number of attacks of sickness, and a

specific number of persons incapacitated for work." I am not concerned for the present with the ratio between death and specific sickness, but recognize that a higher fatality rate does not necessarily bear a continuing direct ratio to the incidence rate. Thus certain diseases in one epidemic have a high mortality rate, and in another a low one, as has been amply demonstrated in epidemics of infantile paralysis and encephalitis, scarlet fever and diphtheria. I desire to present here primarily an analysis of death. It is difficult to select a figure that will adequately make evident the marked hazards from various disease for different age groups.

If one takes the deaths in the city of New York<sup>4</sup> one finds that the average number of deaths from 1900 to 1909 was 73,190, with a rate of 18.32, while in 1929 the total number of deaths was 77,482, and the rate was 11.34. If one considers only the absolute number of deaths one notes a slight increase, although the death rates reveal a remarkable fall. The actual differences are not made clear because the population figures are not given. The ratio of total deaths is 1 to 1.06, indicating that the absolute increase of deaths is exceedingly small; the ratio of death rates, showing a marked decrease, is 1 to 0.62. These figures demonstrate at once, and sharply, the ratio differences.

It is necessary to sense our achievements and accomplishments in affecting mortality, not in blanket rates, but in relative rates at varying ages, and in terms of the relation of these population groups at the varying ages to their own increase or decrease as well as in terms of their relation to the total population increase. It is a significant fact that the percentage of the United States population in the Death Registration Area rose from 41 per cent in 1908 to 97 per cent in 1929, while the death rate in the Death Registration Area during these years fell from 14 to 12. Perhaps it would be more expressive to show the relations between population increase and absolute mortalities than merely to dwell in

terms of mortality rates which do not indicate exactly what has occurred.

Life expectancy during the Middle Ages approximated 21 years; in the United States in 1915 it was 48 years, in 1925, 55 years, in 1926, 57.74 years, and it has since increased to 60 years. These figures arose from an alteration in the incidence of diseases as well as their fatality rates and bear witness to the fact that the greatest improvements have attended the early years of life. Admittedly a change in any death rate, taken as a criterion of social improvement, carries with it many implications. Thus it suggests changes in nomenclature, alterations in diagnosis, increased knowledge concerning the nature of morbidity and heightened therapeutic skill, etc. On the other hand, it may indicate variations in susceptibility to specific illnesses or, indeed, variations in the numbers of people in various age groups exposed to or afflicted by the specific disease.

It is patent that gross measures of mortality at all ages cover up the rise or fall in the mortality at any special age level. Thus, the average aggregate number of deaths from a specific disease covers up the number which occur at any particular age, just as a total mortality rate gives no information concerning the mortality rate from individual diseases. There might be a falling gross mortality rate, with a definite increase in the mortality for some particular age periods. There may be falling gross mortality rates from various diseases which, nonetheless, include an increase of their mortality rates during later decades of life. It is apparent that with the case incidence and fatality rates constant, the number of people dying from any one disease would vary directly with the population. But neither the incidence rate, the fatality rate nor the population are constant. Hence it becomes helpful to contrast the ratio of the total population or a specific age population with the ratio of the number of absolute deaths during any two periods of time. I shall illustrate this without reference to specific diseases.

Dr. Walter F. Willcox<sup>5</sup> shows the age distribution of deaths in the Death Registration section of the United States for 1900 and 1930. The deaths per 100,000 population for varying age groups are indicated in Table II.

TABLE II  
DEATHS PER 100,000 POPULATION

	1900	1930
Under 1 year.....	20,793	9,275
5 to 9 years.....	2,702	1,541
25 to 29 years.....	4,249	2,646
45 to 49 years.....	3,922	5,426
75 to 79 years.....	5,402	9,886

This tabulation gives a sense of values and shows the decrease under one year and the increase above age 45 years, but the decrease is illustrated far better by the following table of ratios, which, on the basis of employing the 1900 figures show the ratios to 1930 data to be as follows:

Under 1 year = 1 to 0.45
5-9 years = 1 to 0.57
25-29 years = 1 to 0.62
45-49 years = 1 to 1.39
75-79 years = 1 to 1.83

This presents more adequately the definite rise above age 45 years, and the marked decrease under age 10, which would be swallowed up in the figures for the general mortality rate. These ratios, however, refer only to death rates and do not show the relation of these rates or ratios to the actual populations of the age groups thus enumerated, any more than they suggest the diseases responsible for the gross figures.

The marked changes in death rates for specific diseases are illustrated, for example, by data from New York State. It is clear that the differential mortality rates are wholly concealed in total death rates of the two years compared. (Table III.)

Herein it is evident that during the twenty-one year period prior to the depression era there had been a modification in the mortality from many diseases. The

TABLE III  
DEATH AND DEATH RATES, NEW YORK STATE<sup>6</sup>

Diseases	1908	1929
Typhoid and paratyphoid.....	15.6	1.3
Diphtheria.....	28.1	5.3
Pulmonary tuberculosis.....	164.1	68.5
Cancer.....	74.7	121.8
Diabetes.....	14.1	26.2
Cerebral hemorrhage, embolism, thrombosis.....	85.1	59.7
Diseases of the heart.....	164.0	293.3
Diseases of arteries.....	24.1	53.1
Pneumonias.....	169.2	124.1
Diarrhea and enteritis under 2 years..	23.8	3.5
Appendicitis.....	10.2	15.2
Acute and chronic nephritis.....	112.6	76.2
Accidents and other violence.....	79.4	81.2

three leading causes of death for 1908 were pneumonia, pulmonary tuberculosis, and diseases of the heart, whereas in 1929 diseases of the heart led, followed by pneumonia and cancer. The falling off of typhoid, paratyphoid, diphtheria and

others suggests the existence of some mixed factors which call for investigation. Thus in New York State, in 1932, the total number of deaths was 146, 639. The first three months in order of fatality significance were March 16, 202; December 14, 075; and April 13, 717. If one plots the various diseases in terms of their fatality prevalence in any one month, one finds that March is attended by the highest mortality rate for pulmonary tuberculosis, diabetes, diseases of the heart, total pneumonia, appendicitis, hernia and intestinal obstruction. This is an unusual mixture of fatal conditions. The month of December was the month of maximum deaths from cancer, cerebral hemorrhage, embolism and thrombosis. April was not a month of maximum deaths from any disease. February and July lacked superiority in any fatality. Perhaps it would also be of advantage to observe these various diseases in the descending mensal order of their fatality—

TABLE IV

Diseases	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Typhoid, paratyphoid.....	..	..	..	..	..	..	..	1	3	2		
Pulmonary tuberculosis and acute miliary tuberculosis.....	..	..	1	3	2							
Cancer.....	2	..	..	..	3	..	..	..	..	..	..	1
Diabetes.....	..	..	1	3	..	..	..	..	..	..	..	2
Cerebral hemorrhage, embolism, thrombosis.....	..	..	3	2	..	..	..	..	..	..	..	1
Diseases of heart.....	..	..	1	..	3	..	..	..	..	..	..	2
Total pneumonia.....	..	..	1	3	..	..	..	..	..	..	..	2
Diarrhea and enteritis under 2 years..	..	..	..	3	..	..	..	..	1	2		
Appendicitis.....	..	..	1	3	..	..	..	2				
Hernia and intestinal obstruction....	2	..	1	..	..	3						
Premature births.....	3	..	..	..	1	2						
Automobile accidents.....	..	..	..	..	..	..	..	..	2	1	2	

tuberculosis is no more striking than the increase in diabetes, diseases of the arteries and appendicitis.<sup>7</sup>

Analyzing the mortality rates in terms of months reveals some rather significant data. The general population does not alter much during the months nor are there notable age variations, and yet the fact that some diseases are far more costly in human lives during some months than in

as typhoid and paratyphoid in August, October, September. (Table iv.)

It is worthwhile noting that while these figures indicate very definitely that the month of March is the most hazardous month in the year so far as fatality from these particular diseases is concerned, there are some diseases which had their highest mortality in May, August, September, October and December. It is important

to note that while these diseases have been rated as first, second and third in series, for some diseases there was comparatively little absolute variation. Typhoid fever, for example, ranged during the months only from 3 to 23; tuberculosis from 523 to 734; cancer from 1,256 to 1,450; diabetes from 245 to 397; cerebral hemorrhage, embolism and thrombosis from 457 to 683, the variation among the three highest months being only from 637 to 683; diseases of the heart from 2,559 to 4,239; pneumonia from 435 to 2,317; diarrhea and enteritis under 2 years, from 50 to 101; appendicitis from 122 to 202, the first three places varying only

which demonstrates another set of facts for the country as a whole. Thus the figures 1, 2 and 3 indicate the months of greatest mortality significance and 10, 11 and 12, the months of lowest mortality, not in terms of rates but in terms of absolute mortality figures during the year. This chart indicates that for the country as a whole during 1929 the month of January was far more fatal than any other month during the year. Thus the environmental factors of the New York State in 1932 find no implication of a duplication throughout the United States during 1929. It is rather significant that the month of May is the

TABLE V

Disease	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
All diseases in the Registration Area	1	3	2				10	11	12			
Typhoid, paratyphoid	10	11	12				3	1	2			
Malaria	10	12	11					1	2	3		
Pulmonary tuberculosis	1		2	3				.	12	10	11	
Diabetes	1	.	3			11	10	12				2
Lethargic encaphalitis	1	2	3				11	10	12			2
Cerebral hemorrhage and softening	1	.	3				10	11	12			3
Other diseases of the heart	1	2	.				10	11	12			
Bronchopneumonia	1	2	3				12	11	10			
Pneumonia	1	2	3				12	11	10			
Whooping cough .	1	..	.				3	2		10	12	11
Influenza	1	2	3				11	12	10			
Diarrhea and enteritis under 2 years	11	12					3	2	1			10
Diarrhea and enteritis 2 years and over	11	12		10			3	1	2			
Automobile accidents	11	12	10				.		1	2	3	
Nephritis	1	..	3				10	12	11			2

from 183 to 202. Hernia and intestinal obstruction varied from 81 to 131, the highest three months varying from 111 to 131; premature Births from 217 to 297, the highest three months varying from 273 to 297; automobile accidents from 194 to 284. Thus it appears that for certain diseases the death distribution through the months of the year 1932 was very nearly equal, indicating that the environmental factor probably was reasonably constant. These figures relate only to New York State for the one year.

I now offer a slightly different set of diseases (Table v) for the Registration Area of the United States for the year 1929,

only month without an allocation of a disease in the category of the very severe or of the very light fatality rates.

If these figures were broken down into the absolute number of deaths from the specific diseases occurring in different topographic areas there would be definite variations of mensal distributions because of climatic differences and differential social phenomena.

Types of lethal diseases may be classified as organic and functional. Among the organic are those whose origins are: (a) infectious; (b) metabolic; (c) traumatic; (d) neoplastic; (e) congenital, hereditary and acquired; (f) toxic.

The prevalence of deaths from infectious diseases such as typhoid and malaria is more dependent upon social factors than that of deaths from measles and scarlet fever, while those from tuberculosis, gonorrhea and syphilis are bound up in personal and social relationships.

The metabolic mortality is related mainly to nutritional problems, save as some are caught up in endocrine diseases. The traumatic group includes deaths from accidental slipping, which may be deemed personal, as well as from accidents incidental to automobiles and other transportation facilities, which involve personal and social relations. So also the deaths arising out of war or some phases of surgery certainly appear to have more social than personal origins. The neoplastic group for the most part may be considered as growing from personal rather than social factors, so far as we know at the present time, despite the suggested high incidence of neoplasms among chimney sweeps, etc. The congenital acquired disorders, so far as they are due to birth injuries may be said to be in part social, though the majority of congenital causes of death involving hereditary factors can scarcely be classified as either personal or social. Toxemic diseases vary from those which are due to industrial poisonings, which largely have their origin in social inadequacy, to deaths from alcohol in which the personal factor is primary, although, of course, alcoholism has its social aspects.

The functional diseases such as neurosis and psychosis, though not regarded as direct causes of death, save suicide, are related to some other diseases of real organic quality such as gastric and duodenal ulcers, and even indeed, to some arteriosclerotic changes, to which I shall refer later. Possibly I should include a separate category of degenerative diseases, which are thoroughly bound up in personal and social factors, and which affect the basic systems of man's organization, such as the heart, the blood vessels and the kidneys. The diseases of the cardiovascular-

renal systems represent in large measure the personal reactions of the individual to social living. They appear to be a consequential expression of man's natural deterioration to the final lesion causing death, for the fact remains that death constitutes a part as well as the end of life.

I have already implied that many diseases have changed in their characteristics. Yellow fever is obsolescent; malaria has diminished; tuberculosis has decreased extensively especially in this country; diphtheria is controllable; typhoid fever has almost disappeared; summer diarrheas are largely traditions. Qualitative changes have appeared in connection with measles, scarlet fever and possibly whooping cough, incidental to factors related to some diminished virulence of the infective organism or virus or to a heightened immunity on the part of a younger generation. On the other hand certain diseases are increasing, such as lethargic encephalitis, poliomyelitis, diabetes, appendicitis, biliary calculus, and the like, in addition to many new forms of poisonings incidental to advancing industrial development. Hence, while plumbism and phossy jaw have disappeared, the incidence of radium poisoning, silicosis, benzol poisoning and the like, has increased.

Mortality as well as morbidity merits consideration as a reaction to living. Perhaps the age distribution of mortality suggests the resistance coefficients of different systems of the organism at different periods of life. The prolongation of life depends upon a harmonious interaction of organ systems and the resistance capacities of the organism as a whole. Certainly longevity, while it may contain a very definite factor from inheritance, also involves numerous elements bound up in what may be termed the art of active living. To live to a ripe old age certainly indicates an organic capacity for adaptation to the stresses of the life to which the individual was subjected. Noting the main causes of death which are still increasing in their ratio at ages 75 to 79, it follows that

in order to achieve a ripe old age, one must escape not only mortality in infancy, childhood and active maturity but such special ailments of middle age as appendicitis, diabetes, intestinal obstruction, biliary calculus and gastric ulcer. Deaths such as those due to cancer and angina pectoris have less significance upon the extension of life than the ability to escape death from an automobile injury. It is strikingly true that the most significant factors in promoting longevity are bound up with the welfare of the gastrointestinal and the circulatory systems.

In ordinary discussions of the prolongation of average life, a tremendous amount of emphasis is bestowed upon heredity, racial characteristics, diet and national tastes, habits of work and play, climate, economics, social position and vocational status, as well as exposure to specific forms of disease. When, however, mortality rates are consulted, it is more or less surprising to find that the most significant causes of death reveal little direct relation to any of these items, at least not upon superficial examination. The increasing ratios of some of the diseases cannot be analyzed in terms of all of these potential factors. It is challenging to find the large amount of mortality due to diarrhea, gastric ulcer, appendicitis and diseases of the gall-bladder, as representative of the maladjustments of the gastrointestinal system. Questions arise from the fact that an organic disease of the heart, such as endocarditis, which apparently has diminished in rate among children and adults up to 45, is increasing at the later ages. Thus, endocarditis had risen as cause of death from third place in 1900 to first place in 1935.

The pneumonias among the respiratory diseases are important lethal agents, but far more significant is the fact that tuberculosis fell from first rank in 1900 to the sixth rank in 1929. The diseases of the excretory system are by no means as prominent as they were, while the neurologic disorders, although tremendously

effective in disorganizing living, seemingly play but a small part in the general scheme of the direct causes of death. Functional disorders and organic diseases of neurologic significance are credited with limited serious responsibility for fatality, except as encephalitis and poliomyelitis in epidemic form take their toll. Even in old age, while neurologic and psychiatric disorders may be active accompaniments, they are not primarily registered as significant causes of mortality.

Raymond Pearl regards old age as being more dependent upon an inherited factor than upon any elements derived from the environment. While this may be true, the evidence for it is by no means certain. The inheritance element depends upon its social struggle. No one can question the fact that social organization has set up environmental conditions predisposing to survival through the control of water supplies, food supplies, food handlers; through the development of efficient health departments, with greater attention to prophylaxis and improved conditions of housing; through public provision for inoculations and vaccines; through great advances in education in personal hygiene, in dietetics, in child welfare, etc. It cannot be gainsaid that the limitation of typhoid and paratyphoid and typhus fevers, the control of diphtheria, yellow fever, bubonic plague and malaria, and the decrease of infant mortality have not been primarily dependent upon personal effort or personal inheritances. The most definite and effective reductions in mortality have been attained through social organization and the coöperative efforts of private agencies and public Departments of Health, Education, Sanitation, and the like, whether at the federal, state, municipal or county level.

It is quite evident that the level of personal hygiene in this country is probably higher than in most parts of the world, considering all levels of population. This does not mean that there is not ample reason for providing opportunities for better personal hygiene, because personal

hygiene of the highest type such as depend upon bathing, garbage and sewage disposal, adequate sunlight and fresh air, can be accomplished only in the light of social provisions. It is evident that heightened social efforts to promote healthful habits of living have involved a greater appreciation of foods, food constituents and food values, the promotion of sane eating habits; the development of recreational programs along with the establishment of adequate hours of rest; the recognition and removal of vocational hazards; a willingness to undertake certain personal and group responsibilities for protection against industrial disease and accidents; and indeed, even a greater appreciation of the value of mental hygiene in terms of diversion, occupation and the promotion of ego values.

This increased personal hygiene has played its part in the general welfare of people. The question arises, however, as to the extent to which this personal hygiene has been effective in diminishing mortality rates from causes which would appear to have some direct relation to the individual's mode of life. This question will receive definite consideration when I discuss specific diseases taking their toll from various age groups. It is obvious, however, that instruction in personal hygiene is less effective than the social application of a principle that compels personal hygiene without choice. If all milk is pasteurized by legal demand, the hazard of milk-borne diseases almost disappears, while the personal knowledge of the value of pasteurization may be disregarded in actual living. Personal hygiene should be a natural by-product of socialized living.

The rise and fall of mortality rates has its greatest significance in terms of the total population of specific groups. It is especially important to note the rise and fall of mortality rates with relation to the rise and fall of population groups at special ages. If, during some unit of time, the total population of any age group doubled and the total number of deaths doubled, the

gross change would be the same but the nature of the combination of diseases entering into the total deaths would be concealed. If one notes the total deaths from any single disease, and plots their rise or fall with reference to the total population for any time sequences, it is possible to observe any marked variations that may occur. This becomes more valuable if the figures for the disease are compared with the numbers of people included in different age groups. It is obvious, therefore, that a study of the changes in the mortality rates at varying ages offers a sensitive approach to the consideration of dominant disease factors, since it demonstrates what has actually happened at particular age sections along the general highway of life. The information thus made available is superior to that derived from a consideration of the total mortality, or a disease rate, which, because it covers up internal variations, is not a refined index of how any specific disease affects our population.

Admittedly, an increasing population would serve as one explanation for a rise in the gross mortality from certain diseases, but this does not explain a rise in the mortality rates. Thus, an increased number of deaths at *all ages* from appendicitis, is understandable without increase in population, but not the higher mortality rate from appendicitis.

I shall present some problems of mortality which appear to indicate that the greatest drop in mortality rates has occurred where social action has been most effective, and that equal accomplishments have not been secured in a large number of diseases where cure has depended upon personally controlled living. Several death causes, now rising disproportionately to the increase of the population, generally, and in terms of specific age groups, should perhaps be placed in the category of diseases of concern from the standpoint of public health. Cannot special action postpone many deaths now apparently inevitable, at ages far too young?

In an analysis of this problem, I have employed the United States population figures 1910 and 1930, even though I shall discuss deaths for the years 1908 and 1929. By rejecting the years from 1930 to 1936, I escape the questions raised by the unusual economic forces of the depression. All data concerning population at the various ages have been secured directly from the United States Bureau of Census. I have not employed the comparative figures because, in 1910 only twenty-one states and the District of Columbia were listed therein, whereas in 1930 all states were included, except Texas and South Dakota. I cannot use the figures for the Birth Registration Area as this was not established until 1915, and there were practically no figures for 1910. It therefore seems more reasonable to employ the figures for the United States census as a whole. The value becomes more obvious, if one considers the total population. For example, in 1908, the total population in the Death Registration Area was 46,790,000, which constituted 52.5 per cent of the total United States population. The death rates in that area for the year 1908 was 14.8 per cent. In 1929, the population in the Death Registration Area was 116,310,000, approximately 95.7 per cent of the total United States population, and in this area the death rate was 11.9 per cent. The total deaths in 1908 were 691,574; in 1929 they had risen to 1,378,675. It is patent that while the death rate dropped from 14.8 per cent to 11.9 per cent (ratio 1 to 0.80) the actual number of deaths rose in the ratio of 1 to 2, while the population ratio had risen to 1 to 2.5. The relation of the total death ratio to the population ratio gives a clearer picture of what happened than the death rates or their ratio. I have completely ignored the change in the urban-rural percentages in the United States, which underwent marked changes between 1908 and 1929.

It appeared wise to choose for special consideration certain age periods which have definite influence in our general wel-

fare. Hence, I have selected deaths under 1 year (prenatal, natal and infancy); deaths 5 to 9 years (childhood), 25 to 29 years (maturity); 45 to 49 years (middle age); 75 to 79 years (old age). I have utilized the absolute figures and have established various ratios of the total number of deaths from specific causes in 1929 with relation to 1908 as a base; also as the occasion required, I have set forth the various population ratios for purpose of comparison. By employing this system of ratios one at once is enabled to note which particular diseases have increased above the general increase for any or all age levels; whether the increase or decrease of mortality deviates from the population increase or decrease of any age group; and which diseases in terms of absolute numbers dying show a differential mortality at specific age levels as opposed to the total number at all ages. (Table vi.)

TABLE VI  
RATIOS 1908-1929

Deaths	Under 1 Year	5-9 Years	25-29 Years	45-49 Years	75-79 Years
Total deaths.....	1:1.07	1:1.6	1:1.5	1:2.2	1:3
Malformations.....	1:1.81				
Congenital heart disease..	1:1.65				
Childbirth.....			1:1.9		
Respiratory system.....			1:1.6		
Disease of digestive system	1:2.4	1:2	1:1.8		
Appendicitis.....	1:5.2	1:3.2	1:3.2	1:4	1:6
Diabetes.....	1:1.66	1:1.7	1:1.7	1:2.5	1:5.5
Cancer.....	1:1.9	1:4	1:2.3	1:4	1:5
Accidental gunshot.....		1:3.1	1:2.3		
Encephalitis.....		1:4	1:9.3	1:4.6	
Lethargic encephalitis....		1:2.4	1:9.8	1:4.6	
Automobile accidents.....		1:45	1:92	1:83.5	1:90.5
Biliary calculus.....			1:3.7	1:3.2	1:3
Gastric ulcer.....			1:2	1:4.3	1:3.8
Intestinal obstruction....			1:2.2	1:2.3	
Circulatory system.....			1:1.7	1:3	1:4
Angina pectoris.....			1:2.1	1:5.7	1:6.7

Table vi presents the ratios for the twenty-one year period from 1908 to 1929. It indicates that the total number of deaths under one year of age had risen only slightly, i.e., in the ratio of 1 to 1.07, while certain definite conditions revealed mortality ratios excessive in comparison with this ratio. Malformations, for example, were above the total ratio levels for the age period, as were deaths from congenital



heart disease. Most noticeable, however, are the heightened ratios of deaths from diseases of the digestive system, appendicitis, diabetes and even cancer.

I am offering ratios and it matters little that the absolute figures for these various diseases may have varied from units to a hundred thousand; the ratios carry a constant value. Thus, if there had been five deaths from a particular disease in 1908, and there were ten deaths in 1929, the ratio would be 1 to 2, just as would be the case if there had been ten thousand dying in 1908 and twenty thousand in 1929. The emphasis rests upon the ratio of absolute numbers rather than in terms of specific mortality rates. Table VI, therefore, demonstrates the actual relative increase of each listed disease, without reference to population rates or ratios. It shows that there was a marked increase in the total number of deaths at ages 45 to 49 and 75 to 79. Further, it makes clear that even within these age groups there are certain specific diseases which stand out markedly with ratios of mortality far above the average mortality ratio for the age group. I shall make the meaning of this more apparent by a contrast between the special disease ratios and the population ratios, as well as the total death ratios for these age periods.

For the moment it suffices to call attention to the fact that appendicitis and diabetes are responsible for higher ratios of death than those representing total deaths for each one of the five periods under consideration, while deaths from automobiles are responsible for greatly increasing mortality ratios in all groups save the first. Even more thought must be given to such outstanding rises in mortality ratios as are presented by biliary calculus, gastric ulcer and intestinal obstruction, especially since these appear to be as significant in the age group 25 to 29 years as the ratios of death from diseases of the circulatory system or angina pectoris.

While some diseases show up especially in the mortality of special age groups, a few diseases markedly evidence an in-

creased mortality throughout the whole range of life from infancy to old age. Appendicitis, diabetes and cancer are outstanding, as are biliary calculus, gastric ulcer, diseases of the circulatory system and angina pectoris, whose havoc becomes manifest from the age of maturity onward through old age. While ratios of deaths from automobiles cover all periods save the first, the tremendous increase of the figures is due mainly to the fact that automobiles were less prevalent in 1908 than in 1929 and hence the possible exposure to this cause of death was much less.

The chart as a whole, clearly reveals some trends of mortality above those implied in the general mortality trends of the age. This is perhaps more evident in Table VII which, however, is based only upon the deaths of New York City males for a three year average and reflects the percentage of mortality taken by various diseases at each age. This table shows that pneumonia as a single cause is highly operative at each age level. It gives, however, no indication as to whether the pneumonia fatality or any other mortality is higher than the general mortality level of all diseases for the age period. It indicates the five chief causes of death in certain large age groups based upon the average number of deaths of males per year in New York City, 1932-1933-1934. The chart shows the percentage of total deaths in each one of the age groups, stressing only the five main causes of death.<sup>1</sup>

Table VII is wholly inadequate for giving the type of information available in Table VI, as it affords no evidence of the dynamics of a disease in terms of its rise or fall with relation to the general mortality ratio at any age, or with relation to the population changes or aught else.

It is generally stated that infant mortality rates have greatly diminished, but certainly Table VI indicates that some marked problems in infant mortality continue to demand attention. A rising mortality at later ages is to be expected, but as will be

TABLE VII  
NEW YORK CITY MALES 1932-1933-1934: PERCENTAGES  
OF TOTAL DEATHS

	Under 1 Year	5-8 Years	25-29 Years	45-54 Years	65 Years and Over
Premature births	28				
Malformations and debility	10				
Other diseases of early infancy	16				
Pneumonia	21	11	9	9	8
Diarrhea	9				
All other causes	16	40	35	35	19
Accidents		27	16	9	
Heart disease		9			
Ear and mastoid		7			
Appendicitis		6			
Tuberculosis			23		
Circulatory diseases			11	31	49
Suicide			6		
Cancer				12	14
Nephritis				4	7
Diabetes				.	3
Puerperal diseases (for female group)		..	15		

found later, the rises in mortality are not dependent wholly upon increases in population. It is helpful to consider the general mortality ratios of different age groups during 1908 and 1929 and then to determine which disease ratios rose above them, recognizing, of course, that the total ratios as averages are affected by the fact that some disease ratios are high and others are low. The contrast between the average mortality ratio and the special higher mortality ratios indicates where certain problems of public health await solution.

Admittedly the greatest mortality rate should occur above age 60. Under ordinary conditions one would expect the deaths of the aged to be due largely to such degenerative diseases as arteriosclerosis, chronic nephritis, myocarditis, cerebral hemorrhage and the like. Table VI, however, indicates that certain causes of fatality are operative which are not peculiar to old age. These have risen disproportionately beyond the

actual increase of total deaths to such an extent as to indicate that they merit consideration for reasons not inherent in the normal aging processes.

#### CONCLUSIONS

Changes in nomenclature, advances in diagnoses, gains in surgical technique operate to modify the validity of statistical statements. Recognizing the weakness of a statistical presentation there can be little question that the morbidity and mortality rates of this country are undergoing marked changes at all age levels. There is ample evidence that certain forms of disease have increased proportionately to population increase or decrease, and that a few diseases, particularly those related to the gastrointestinal system, show an excessive mortality ratio despite our gains in medical and surgical therapy. The gastrointestinal and the circulatory diseases, along with cancer and automobile accidents, constitute a present day challenge which cannot be ignored. The physician and surgeon alike are concerned with the prevention of unnecessary death which means all except those over age 60.

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# GASTROSCOPY AS AN AID IN THE DIAGNOSIS OF CARCINOMA OF THE PANCREAS

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CARCINOMA of the pancreas is one of the most difficult of the upper abdominal lesions to diagnose, especially if not associated with jaundice or a palpable tumor mass. From a diagnostic standpoint it is therefore fortunate, as Clute has pointed out, that most carcinomas of the pancreas occur in the head of the organ and, consequently, are associated with jaundice. Eusterman and Wilbur, however, have found from a review of 403 proved cases of carcinoma of the pancreas that one may anticipate an absence of jaundice in more than 20 per cent.

It is in this latter group of patients that the physician's diagnostic skill is sorely tried. Carcinoma of the pancreas should be suspected in any individual of middle age who complains of a deep-boring upper abdominal pain of short duration, relieved by bending forward, and associated with a rapid loss of weight. Confirmatory evidence, however, is very sparse. An epigastric mass is extremely significant but it is more often absent than present. Eusterman and Wilbur have aptly stated that, in spite of the stress that has been placed on the presence of glycosuria and steatorrhea in the diagnosis of carcinoma of the pancreas, these findings are conspicuous by their absence. Changes in the pancreatic ferments are infrequently present, and when present are of doubtful value. The same may be said of study of the gastric contents. The procedure that, up to the present, has probably been of the greatest value in the recognition of carcinoma of the pancreas is roentgenographic study of the gastrointestinal tract. While roentgenograms often suggest involvement of the pancreas, more often the diagnosis must await exploratory laparotomy.

It is, therefore, readily apparent that any procedure which might assist in earlier and more accurate recognition of such a highly fatal disease is worthy of report. It has been our good fortune to find gastroscopy of value in the diagnosis of two cases of carcinoma of the pancreas in the absence of jaundice or of a palpable tumor mass, and we feel that this is worthy of report, as it may be of value to other observers in arriving at an accurate and earlier diagnosis of this malignant disease.

That gastroscopy should, theoretically, be a suitable procedure as a diagnostic aid would seem apparent from a review of the anatomic relationship of the pancreas to the stomach. The anterior surface of the body of the pancreas forms a considerable portion of the bed of the stomach. Theoretically, any involvement of this portion of the pancreas should cause a change in contour of the adjacent stomach wall which should be recognized gastroscopically and lead to a correct diagnosis. (Fig. 1.) That this does occur is seen from the two following case reports.

CASE 1. A man 56 years of age first came under our observation at The Mayo Clinic in June, 1937 because of attacks of pain in various joints of his body. These attacks had been present in cycles during the preceding thirty years. A diagnosis of gout and obesity was made, the patient was placed on a purine-free diet and cinchophen was administered. He made definite improvement and was permitted to return home. He did very well on this regimen except for one severe attack of gout. In October, 1937, while away from home on a business trip and under considerable nervous strain, he took cinchophen one night without water. He awoke the following morning with a dull pain in the epigastrium, which was ascribed to the cinchophen. The pain con-

tinued, gradually becoming more severe and constant, so that he was unable to work or rest. Two weeks later the pain began to extend into

and that of blood uric acid was 5.2 mg. per 100 c.c. Examination of the stools for occult blood and fat gave negative results. Studies of

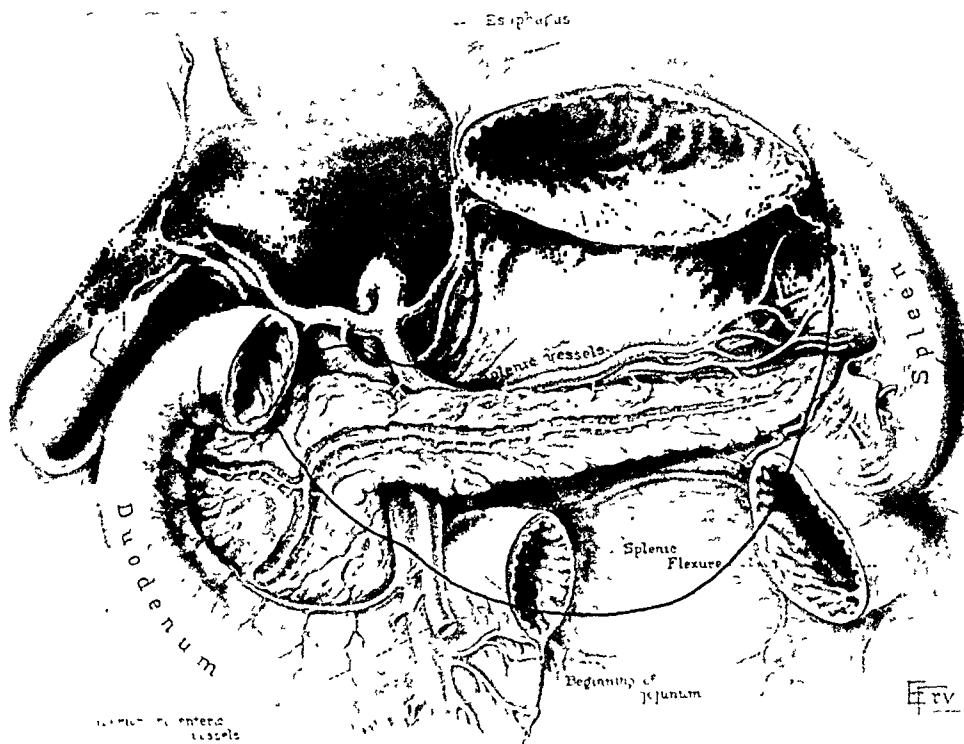


FIG. 1. Diagram showing relation of pancreas to stomach.

the right renal region. There was no associated nausea, vomiting, or urinary symptoms. His appetite rapidly failed and there was a marked loss of weight. There were no tar-colored stools. The patient obtained relief by assuming a sitting position.

He returned to The Mayo Clinic on November 11, 1937 for further examination, just a month following the onset of his pain in the epigastrium. Physical examination revealed that he was well developed and well nourished but obviously he had lost considerable weight. The only physical finding of any significance was tenderness in the epigastric region; no tumor mass was palpable. Laboratory studies revealed the following results:

The concentration of hemoglobin was 14.1 Gm. per 100 c.c. of blood, and there were 4,530,000 erythrocytes and 5,800 leucocytes to the cubic millimeter of blood. The Wassermann reaction of the blood was negative, as were the results of the urine examination. The sedimentation rate was 32 mm. per hour. The concentration of blood sugar was 87 mg. per 100 c.c.,

the liver function, gastric contents, amylase and lipase in the serum failed to reveal anything of importance. Roentgenographic studies of the kidneys, ureters, urinary bladder, stomach, and colon gave essentially negative results. A roentgenogram of the small bowel was not satisfactory. Roentgenographic examination revealed a poorly functioning gallbladder. This, however, did not seem adequate to account for the patient's symptoms. Intravenous urograms, as well as cystoscopic studies, were made to rule out the kidney as a possible source of difficulty, but these all gave negative results.

The patient's pain became progressively worse and it became necessary to resort to morphine for its control. A neurologic examination failed to reveal anything of diagnostic importance.

The severity of the epigastric pain, its recent onset in a man of 56 years of age, and the progressive loss of weight and strength, together with the absence of demonstrable lesions of the upper urinary and digestive tracts and of

the central nervous system, comprised a combination of findings pointing with a fair degree of certainty to the pancreas as the seat of a

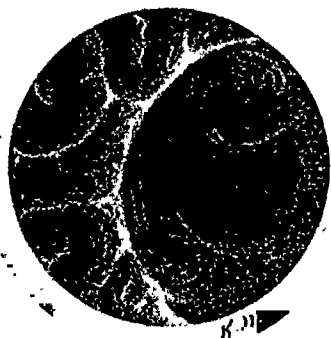


FIG. 2. Gastroscopic appearance of bulging of mucosa produced by pancreatic tumor.

neoplastic growth. There was little, however, from the physical or laboratory side to confirm such a diagnosis.

With this information at hand, the patient was examined with a gastroscope on November 24, 1937 and the following conditions were observed (Fig. 2): On the posterior wall of the stomach, above the angle, there was a bulging forward of the mucosa into the lumen of the stomach which could not be obliterated by inflation of the stomach with air. There were also stiffening and thickening of the mucosa over the region involved. It was uncertain whether the tumor mass originated in the gastric wall itself or extragastrically, pushing the stomach wall forward. It seemed to us, however, that the condition was most likely a tumor originating in the pancreas.

With this information, a tentative diagnosis of carcinoma of the body of the pancreas was made and exploratory laparotomy advised. This was performed on December 2, 1937 by Dr. Pemberton, who found a mass larger than a fist involving the body and the tail of the pancreas. It was firm in consistency and nodular in character. An aspirating needle was inserted into the mass and a specimen obtained, which on microscopic examination was diagnosed as malignant. The gall-bladder was also examined and found to be large and flaccid, but no stones could be felt.

The patient continued to fail and died February 3, 1938. The findings at necropsy confirmed the diagnosis of carcinoma.

CASE II. A woman 58 years of age first came to the clinic January 3, 1938, complaining of indigestion. She stated that she had enjoyed good health until three months before. At that time she had first noticed a dull, constant, aching pain in the lower left anterior portion of the chest, which was severe enough to keep her awake at night. Six weeks later the pain had become intermittent in character and had shifted to the midepigastriac region. It was aggravated by eating and somewhat relieved by belching. With the shift in location of the pain there was also projection along both costal margins and then to the left shoulder blade. The patient was frequently awakened at night by the pain, and would have to get up and walk the floor. There was no nausea or vomiting, but there had been a loss of appetite and a decrease of 30 pounds (14 kg.) in weight during the month preceding our examination. At no time were there clay-colored or tar-colored stools, chills, fever or jaundice.

On physical examination the patient was found to be well developed, but she had obviously lost weight. She weighed 150 pounds (68 kg.), as compared with 180 pounds (82 kg.) one month previously. The blood pressure was 122 mm. of mercury systolic and 80 diastolic, the pulse rate was 74 per minute, and the temperature was 98.4° F. The results of physical examination were essentially negative. The results of urinalysis, the concentration of hemoglobin, erythrocyte and leucocyte counts, and the flocculation reaction for syphilis were all essentially normal. Gastric analysis failed to reveal anything abnormal. Roentgenographic studies of the gall-bladder, stomach and colon gave negative results. Electrocardiographic tracings also were normal.

Because of the location and character of the pain, gastroscopy was advised. This was performed January 6, 1938, under local anesthesia. At the junction of the middle and upper thirds of the stomach the posterior wall of the stomach was pushed forward and appeared nodular in character. The gastric mucosa overlying this region seemed infiltrated and it was impossible to say whether the condition was a beginning infiltration or gastritis.

Because of these findings and the character of the patient's symptoms, surgical exploration was advised; it was carried out on January 15, 1938 by Dr. Walters. On opening the abdomen, a carcinomatous nodule 5 cm. in diameter was

found in the lower margin of the left lobe of the liver. The primary lesion appeared to rise from the tail of the pancreas and was the size of a fist. The portion of the stomach in contact with the tumor was not involved in the malignant process but appeared to be involved in gastritis. The patient recovered from the exploration but died at home several months later.

It is readily apparent that gastroscopy is of value only in the recognition of tumors involving that portion of the pancreas that comes in contact with the stomach. This, however, is precisely the region in the pancreas in which it is most difficult to arrive at an adequate diagnosis. Whether gastroscopy may be of value in the diagnosis of carcinoma involving the head of the pancreas is very doubtful, and we have had no experience with such lesions gastroscopically. As a rule, however, lesions located in that portion of the pancreas give rise to jaundice, which attracts attention to the correct underlying disease.

While two cases are hardly sufficient to permit one to discuss differential diagnosis, there are two conditions seen gastroscopically that might simulate a tumor of the pancreas. The first is an exaggerated anterior curvature of the lumbar segment of the vertebral column, which may cause a bulging forward of the posterior wall into

the lumen of the stomach. This, however, does not produce a nodular type of bulging and does not have an associated thickening of the overlying gastric mucosa.

The second condition that may simulate carcinoma of the body of the pancreas gastroscopically is a cascade type of stomach. Here likewise, owing to the sharp angulation of the stomach on itself, one gets the impression of something bulging forward into the lumen. On inflation of the stomach with air this bulging tends to disappear, which is not true of bulging due to an underlying tumor.

There is no reason, of course, why enlarged retroperitoneal glands might not give rise to a gastroscopic picture similar to that seen in tumor involving the body of the pancreas.

Whether further experience will demonstrate that gastroscopy is of greater value than other diagnostic procedures in cases of carcinoma of the body of the pancreas must await further observation and study.

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# PEDUNCULATED GASTRIC TUMORS

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**P**EDUNCULATED gastric tumors are responsible for some of the most interesting symptom complexes encountered in the upper abdomen. These lesions are not common, but can by no means be considered rare. Consideration in differential diagnosis that such a lesion may be present, together with the increasing skill of the radiologist in visualizing these tumors, has resulted in removing them from the group of pathologic curiosities.

## INCIDENCE

Exact figures on the incidence of pedunculated gastric tumors are difficult to obtain. Many isolated reports of such lesions, presenting varying types of pathology are to be found in the literature, but few have had the privilege of studying any sizable group of cases. The incidence of gastric tumors which are benign has been estimated by several different writers: Minnes and Geschickter<sup>1</sup> 4.5 per cent; Eusterman and Senty<sup>2</sup> 1.3 per cent; Douglas<sup>3</sup> 2.9 per cent. Eusterman and Senty, in 1922, reported twenty-seven cases of benign gastric tumor observed over a fourteen-year period at The Mayo Clinic, of which 25 per cent were capable of blocking the pyloric outlet. During the same period 2,168 patients with gastric carcinoma were operated upon, and an additional group of 2,285 cases of gastric malignancy were denied surgery due to the extent of the disease. Balfour and Henderson<sup>4</sup> have observed fifty-eight cases of benign gastric neoplasm, of which 10 per cent were sufficiently mobile to produce pyloric obstruction. Eliason, Pendergrass and Wright,<sup>5</sup> in 1926, collected 611 cases of benign gastric tumor, of which forty-eight,

or 7.5 per cent, were pedunculated. These authors personally studied a series of fifty benign gastric tumors of which ten, or 20 per cent, were pedunculated.

## ETIOLOGY

The cause of solitary pedunculated gastric tumors remains as obscure as that of neoplasms in general. The vast majority, however, must take their origin as simple, benign, epithelial tumors in the gastric mucosa, or as mesothelial tumors in the submucosal tissues. With growth and extension into the lumen of the stomach the expulsive action of the gastric peristalsis attempts to extrude them toward the pylorus and results in the development of a definite pedicle. Eliason and Wright<sup>6</sup> suggest that these new growths take their origin in a low grade inflammatory reaction in the mucosa resulting from chronic irritation. Johnson<sup>7</sup> believes that chronic alcoholism, chronic gastritis, atheroma of the gastric vessels, and conditions leading to chronic nutritional disturbances of the stomach are responsible. This author feels that chronic gastritis is probably the most common etiologic factor, resulting in hypertrophic thickening and lobulated swelling of the gastric mucosa, which leads to the development of the polypoid formation. The common association of an achlorhydria, together with the relatively high incidence of gastric polyps in proved cases of primary pernicious anemia coming to post-mortem, would tend to support this suggestion.

In the instance of diffuse gastric polyposis or adenopapillomatosis gastrica, it is possible that other factors play a part. Brunn and Pearl<sup>8</sup> suggest that this condition may arise either on a congenital or a

familial basis, due to fetal epithelial anlage plus chronic inflammation, or simply as a result of prolonged chronic inflammation of the gastric mucosa.

#### PATHOLOGY

From a gross pathologic standpoint pedunculated lesions of the stomach may be classified under four major headings: (1) solitary benign gastric tumors which, as a result of growth and gastric motility, develop pedicles; (2) malignant pedunculated gastric tumors, usually representing carcinomatous degeneration of a preëxisting benign polyp or adenoma; (3) diffuse gastric polyposis, adenopapillomatosis gastrica, or gastritis polyposa; and (4) prolapsing prepyloric gastric mucosa.

Solitary benign gastric new growths may appear as myomata, papillomata, polypi, myxomata, adenomata, cysts, lipomata or fibromata. Minnes and Geschickter have divided all benign gastric tumors into four groups according to the tissue from which they take their origin: epithelial, mesenchymal, endothelial, and a mixed group including cysts. In a series of 931 collected cases they found that the epithelial tumors comprised 35.2 per cent, the mesenchymal tumors 65.9 per cent, and the other two groups 10 per cent. Eliason and Wright<sup>6</sup> found that in their series of fifty cases, papillomata and polypi represented 64 per cent of the group, with adenomata next in frequency (10 per cent). Balfour and Henderson report that 24 per cent of their group of fifty-eight benign gastric tumors were fibro-adenomatous polypi, and 40 per cent were fibromata, myomata and myofibromata. In Eusterman and Senty's series of twenty-seven benign gastric tumors, myomata were the most common (38 per cent), with fibromata and polypi next in order (30 per cent).

The striking frequency with which these solitary benign gastric lesions are found in cases diagnosed as typical primary pernicious anemia is worthy of note. Brown,<sup>9</sup> in a series of 151 cases of primary pernicious anemia studied at post-mortem, found

gross lesions in the gastrointestinal tract in eighty-two. There were thirteen benign tumors in this series, twelve in the stomach and one in the jejunum. Four of these were myomas, eight were epithelial polyps and one was a mixed tumor.

These benign tumors of the stomach may vary in size from a few millimeters up to rather massive dimensions. Bland-Sutton<sup>10</sup> reports a myoma weighing 7 pounds.

Gastric fibromata, adenomata and simple polypi tend more commonly to arise in the body and pyloric end of the stomach. They are usually found to take their attachment from the anterior or posterior surfaces of the stomach and more rarely from the curvatures. With continued growth they project into the gastric lumen and tend to develop their pedicles as a result of peristaltic activity. The average length of the pedicles in the reported cases has been 2 cm., but many of these become much longer as the tumor increases in size. Their proximity to the gastric outlet results in the frequent production of pyloric obstruction, usually of a ball-valve, intermittent type. Balfour and Henderson observe that this occurs in approximately 10 per cent of the solitary benign gastric neoplasms. The other frequent complications resultant from these solitary benign tumors are intussusception, ulceration, gastric hemorrhage and malignant degeneration.

Malignant pedunculated gastric tumors usually represent examples of carcinomatous degeneration in a preëxisting adenoma, polyp or papilloma. The incidence of malignant degeneration in these lesions has been varyingly estimated by different authors: Stewart<sup>11</sup> 28 per cent; Brunn and Pearl<sup>8</sup> 12 per cent; Myer and Brams<sup>12</sup> 60 per cent; Miller, Eliason and Wright<sup>13</sup> 35 per cent, and Benedict and Allen<sup>14</sup> 41.2 per cent. McRoberts<sup>15</sup> found definite malignant degeneration in the epithelium about the periphery of the pedicle in four out of five gastric polyps. Pennington<sup>16</sup> has also pointed out that it is in the gastric mucosa adjacent to the pedicle that neo-



plastic change is usually first evident. Walters<sup>17</sup> calls attention to the interesting clinical fact that in diffuse gastric polyposis malignancy is not the rule, while in solitary gastric polypi malignancy occurs with great frequency.

The presence of a definite gastric carcinoma separated by normal mucosa from an associated benign polyp has been reported by Douglas.<sup>3</sup> This patient succumbed after a recurrence fifteen months after a gastric resection. The case which we are reporting presented very similar findings at operation. Cases of this type demonstrate the narrow margin that exists between an apparently benign gastric polyp or adenoma and a gastric malignancy. This is responsible for the surgical dictum that all gastric polypi should have the advantage of radical surgery if feasible. Sinclair,<sup>18</sup> after a study of these cases, concluded that "adenomatous polypi of the stomach, whether single or multiple, must be accepted as definitely precancerous lesions, but the available evidence goes to show that the association is much less intimate than in the case of the large intestine."

Diffuse gastric polyposis or adenopapillomatosis gastrica represents a rare type of gastric lesion, characterized by the presence of multiple pedunculated or polyp-like tumors. Higgins<sup>19</sup> divides this group of tumors into three distinct types from a pathologic standpoint: (1) polyadenoma polypeux—consisting of polyps with multiple cysts, possibly due to obstructed ducts; (2) polyadenoma en nappe—with numerous polyps in clumps or plaques; and (3) polyadenoma of Brunnerian type—containing duodenal glands (quite rare).

Mills<sup>20</sup> was able to collect fourteen cases of multiple gastric polypi from the literature prior to 1922. In this series the number of polypi varied from six to over 250. He could find no evidence of inflammation in the mucosa between the tumors and does not believe that an inflammatory reaction is important in their production. Strauss, Meyer and Bloom,<sup>21</sup> in 1928, re-

ported two cases of polyadenoma en nappe, bringing the reported cases of this type to seven. In both of their personal cases the lesion was primarily limited to the fundus of the stomach and characterized clinically by gastric discomfort, repeated gastric hemorrhages, and abnormal amounts of gastric mucus of an egg-white consistency.

The two major complications that may develop with this type of gastric polyposis are hemorrhage and malignant degeneration, although the latter is not nearly so common as in the instance of a solitary prepyloric gastric polyp. Oshner and Moser<sup>22</sup> have recently reported two cases of multiple gastric polypi, one succumbing with metastasis and the other with massive gastric hemorrhage. Joyce and Diack<sup>23</sup> have also observed a patient with diffuse gastric polyposis treated by a Polya type of gastric resection; this individual succumbed eighteen months later from metastasis.

Prolapsing gastric mucosa must be considered for the sake of completeness in any discussion of pedunculated gastric tumors. This condition is not in any way neoplastic, but represents a redundancy of the prepyloric mucosa of a varying degree, prolapsing through the pyloric ring with the development of intermittent pyloric obstruction. Pendergrass and Andrews<sup>24</sup> report eight cases of this condition diagnosed by x-ray, with subsequent confirmation on surgical exploration in seven instances. The condition clinically and roentgenologically may simulate the picture presented by a pedunculated gastric polyp and these authors state that in their experience it is often impossible to differentiate between the two by x-ray examination.

#### SYMPTOMS

The majority of patients with pedunculated gastric tumors are males between the ages of 40 and 65. Monat,<sup>25</sup> however, observed a 12 year old girl with a gastric intussusception incident to a gastric polyp, and isolated cases have been reported in almost every decade of life.

Pedunculated tumors in the body of the stomach produce symptoms varying with their location. Those near the pylorus may produce intermittent ball-valve obstruction with attacks of severe epigastric pain, nausea and vomiting. This obstruction is usually transient and is relieved when the tumor falls back into the body of the stomach. Instances are recorded in which the patient was conscious of something slipping or moving in the epigastrium just before the beginning of an attack, as noted in our patient. These patients often find that changing their position, or taking fluid will dislodge the obstructing tumor mass and give relief.

Those tumors situated sufficiently far from the pylorus to prevent the development of intermittent obstruction may only produce symptoms of vague epigastric discomfort of an indefinite type. Gossett et al.<sup>26</sup> found that in twenty-seven of a series of sixty-six collected cases of pedunculated gastric tumors there were no symptoms to attract attention to the stomach. These patients usually seek medical relief because of a sudden gastric hemorrhage which may be massive enough to be fatal, or because of weakness resulting from chronic blood loss. The bleeding in these cases results from either torsion of the pedicle with partial strangulation, or more commonly from an ulcer which develops on the surface of the pedunculated tumor.

It is interesting to note that some of these patients who bleed slowly over a period of time develop glossitis, achlorhydria, diarrhea and a blood picture which is indistinguishable from primary pernicious anemia. Waters<sup>17</sup> reports three cases of bleeding gastric polyps occurring in patients with primary pernicious anemia, all successfully removed with improvement. Priestley and Heck<sup>27</sup> observed three cases of typical primary pernicious anemia, with established neurologic signs, in each of which on routine gastrointestinal examination there was found a bleeding gastric

polyp. All three were definitely improved by surgical removal of the polyp.

Isolated cases have been reported by different authors in which the only symptoms and physical findings elicited were those incident to profound anemia, with or without vague epigastric symptoms, and on routine gastrointestinal studies a gastric polyp was discovered. These observations emphasize the importance of a thorough x-ray study of the upper gastrointestinal tract in every case of severe anemia, including those which appear to be clear-cut cases of primary pernicious anemia.

In addition to obstruction, ulceration, and hemorrhage, the other common complication encountered with pedunculated gastric tumors is intussusception. Iceton et al.<sup>28</sup> report a neuroblastoma of the gastric wall producing a fatal intussusception through the pylorus in a 47 year old female. Other instances of gastroduodenal and gastrojejunal intussusception have been reported by Wade,<sup>29</sup> Monat,<sup>25</sup> Barnett,<sup>30</sup> and Shuman and Cruikshank.<sup>31</sup>

#### DIAGNOSIS

The symptomatology of pedunculated gastric tumors is so varied that no one picture can be considered diagnostic. However, these lesions should be kept in mind and suspected when a history is elicited of vague epigastric distress with bouts of intermittent pyloric obstruction, especially if accompanied by achlorhydria and anemia. A routine physical examination is rarely of assistance in establishing the diagnosis, for the vast majority of these tumors cannot be palpated. A careful x-ray examination by a competent radiologist is the chief method of diagnosis in each instance. Lockwood<sup>32</sup> states that the principal sign of a mural, sessile or pedunculated growth in the stomach is the round or oval shaped filling defect seen radiographically. Peristalsis is not interrupted and the tumors can usually be shifted about in the stomach. Kirklin and Broders<sup>33</sup> caution that the stomach should

be absolutely empty before the examination is undertaken and that a small amount of thin barium be used to permit accurate visualization of the gastric contours. They found that food masses, simple hypertrophy of the gastric mucosa and non-ulcerated polypoid carcinoma were very easily confused with pedunculated gastric new growths. Pendergrass<sup>34</sup> and Rigler<sup>35,36</sup> have outlined the most common x-ray findings seen in the examination of these patients. These have been summarized by Pendergrass<sup>34</sup> as follows:

1. A filling defect not easily demonstrated by fluoroscope. When seen it is sometimes possible to palpate the lesion.
2. Peristalsis is not often interrupted unless there is an associated carcinoma with infiltration of the gastric wall.
3. A six-hour gastric residue is usually present.
4. A central filling defect in the duodenum is seen on x-ray in the prone and right oblique positions.
5. No defect is noted in the stomach in the pyloric region. This is important in differentiating prolapsing tumors from prolapsing prepyloric mucosa.

La Roque and Shiflett<sup>37</sup> observe that in general it may be assumed that "a filling defect suggesting a new growth in the duodenal bulb, accompanied by a six-hour residue, is indicative of a prolapsing tumor, while the absence of the six-hour residue is indicative of the tumor arising in the duodenum itself."

The most common lesions which may be confused in the differential diagnosis include gastric and duodenal ulcer, gastric carcinoma, prolapsing gastric mucosa, mesenteric bands and hypertrophied pyloric muscle in the adult. A careful evaluation of the history and physical findings may give some assistance in differentiation, but the principal burden falls upon the radiologist. Those who have had experience with this type of lesion are capable of correctly diagnosing their presence in a high percentage of cases and it is upon the radiologist that the surgeon must depend.

## TREATMENT

The treatment of prolapsing gastric tumors is surgical. The tendency of these new growths to ulcerate, bleed, obstruct and undergo malignant degeneration is well established. Surgical treatment should include a radical removal of the tumor together with the adjacent stomach, since the carcinomatous degeneration so frequently first develops about the base of the pedicle. It is quite true that in dealing with a simple pedunculated fibrinous polyp, local removal of the polyp might be adequate, but this type of procedure is in general a dangerous one to follow. Numerous reports are to be found in the literature of recurrence and subsequent death from metastasis following conservative surgical procedures in the treatment of these tumors. The wiser course is to follow the advice of Balfour<sup>38</sup> and subject these cases to partial gastrectomy rather than a local excision if the patient's condition permits, and in this way remove the local area of the stomach and assure safety from recurrence.

Since the majority of these solitary prolapsing gastric polyps arise in the body or prepyloric region of the stomach, some form of partial gastrectomy will completely remove the entire area of stomach under suspicion. When one encounters a bleeding pedunculated tumor in the cardia of the stomach however, local excision with removal of as much of the adjacent mucosa and gastric wall as is feasible is the only course possible.

It is worthy of note that often the operating surgeon will be unable to demonstrate the presence of the pedunculated tumor through the gastric wall when the abdomen is first opened. They have a tendency to be very elusive, depending upon the size and the length of their pedicles. Accordingly they may be found anywhere from the cardia to the second or third portions of the duodenum. If the diagnosis of a pedunculated tumor has been made by a competent radiologist, its absence cannot be definitely established until the stomach

has been opened and the entire inner surface carefully examined under direct vision. Only if this step has been carried out is one justified in assuming that the tumor is not there and an error has been made in diagnosis.

The following case, recently observed, demonstrates most of the prominent features that characterize these lesions. It is of interest in that a correct diagnosis was made by the radiologist of a prolapsing prepyloric gastric tumor before operation and the presence of an associated gastric carcinoma in the body of the stomach was also suspected.

#### CASE REPORT

J. W., a white male farmer, 58, was seen in consultation with Dr. Frank Conlin at St. Catherine's Hospital on February 4, 1937. The patient was admitted with an initial complaint of recurrent attacks of epigastric pain for a period of six months.

There was no history of any previous serious illnesses. The patient had done hard manual work until the onset of the present illness and always considered himself to be in excellent health.

Six months before admission the patient first became aware of what he described as a "weak" feeling in his epigastrium, unassociated with any pain. He then noted the development of rather severe attacks of epigastric pain, beginning in the mid-epigastrium and radiating to each side of the midline for a distance of 15 cm. This pain was dull in type, usually came on at 3 or 4 o'clock in the morning, and was promptly relieved by sitting up in bed or drinking a glass of milk. After eating his morning meal the patient was able to do his day's work without any discomfort. Pain was rarely experienced during the day, but occasionally the patient noted a sensation of "weakness" in the pit of the stomach. Coarse foods were especially prone to produce this sensation but no other foods were troublesome. Occasionally something seemed to move or slip in the epigastrium and following this sensation pain would develop about the pylorus. Three months before admission the patient was operated upon elsewhere for a rectal fistula. He had some bright red blood in his stools prior to this operation but none since. There had been no nausea

or associated vomiting, and no change had been noted in the bowel habit. The patient denied any loss of weight or strength. The



FIG. 1. X-ray examination of stomach demonstrating pedunculated gastric polyp in prepyloric region and defect on greater curvature resultant from coexistent gastric carcinoma.

major complaint was the periodic attacks of epigastric pain which gradually increased in severity and frequency during the previous four months.

The patient was well developed and in a good state of nutrition. He did not appear to have lost any weight. The teeth were in poor condition, the tonsils small and the throat slightly injected. There were no palpable glands in the neck. The chest was clear on percussion and auscultation. The heart was not enlarged, the sounds regular and of good quality, with no murmurs. Blood pressure was 140/90. There was no abdominal distention and no scars or hernia were present. There was slight but definite resistance over the epigastrium on palpation and a little deep tenderness was demonstrable over this region. No masses could be made out. The extremities and reflexes were all normal.

#### Laboratory Data.

Blood hemoglobin 90 per cent R. B. C. 5,000,000. W. B. C. 6,100.

Differential: Polys 55 per cent (staph. 1 per cent, seg. 54 per cent); lymphocytes 38 per cent, eosinophiles 7 per cent.

Urine: Specific gravity 1.007; no albumin, sugar or acetone; occasional white blood cells.

Wassermann negative.

Stool examination: Negative for occult blood and for parasites on three occasions.

appeared irregular, suggesting the possible presence of a carcinoma in this area in addition to the polyp.



FIG. 2. Resected portion of stomach opened to show the size and shape of the gastric polyp and attachment of its pedicle.

#### Gastric Analysis:

	Minutes			
	15	30	45	60
Free	0	0	0	0
Total	32	14	10	10

A gastrointestinal examination showed that the stomach filled poorly at the pyloric end and disclosed a constant defect visible there and at the base of the duodenum, which looked like that produced by a pedunculated polyp arising in the adjacent pylorus. (Fig. 1.) At five hours the stomach was practically empty. The small bowel showed no abnormality. At twenty-four hours the colon was irregularly filled with the meal. A barium enema showed no apparent lesion in the colon.

A recheck of the stomach after twenty-four hours showed essentially the same picture seen at the first examination. The roentgenologist concluded that there was a pedunculated tumor in the duodenum, probably arising in the prepyloric stomach. The adjacent pylorus

*Operation.* Under avertin and open drop ether, the abdomen was opened through a right rectus incision. Examination of the stomach showed a typical area of carcinoma on the greater curvature and anterior surface, 4 cm. in diameter. This lesion was 3 inches proximal to the pylorus and had invaded the peritoneal surface of the stomach. Palpable within the prepyloric stomach was a pedunculated intra-gastric tumor, which could be pushed through the pylorus into the duodenum for a distance of 3 cm. and back into the body of the stomach. This tumor seemed to be about 2 cm. in diameter and when prolapsed into the duodenum effectively blocked its lumen. There was no evidence of metastasis in the liver, the regional gastric nodes or pelvic peritoneum.

The gastric polyp was replaced into the prepyloric stomach and a gastric resection carried out, removing the distal half of the stomach well above the carcinoma, together with the pyloric ring. A Billroth type I reconstruction was then carried out, employing the modification suggested by Horsley. The anastomosis was completed without tension and the patient returned to his room in excellent condition.

Convalescence was entirely uneventful. A postoperative ulcer diet was given five days after operation. The patient was dismissed from the hospital on the fifteenth postoperative day. He remained entirely well for fourteen months, and is doing hard work on his farm with no complaints.

**Pathologic Report.** The specimen consisted of the distal half, together with the pylorus of the stomach. (Fig. 2.) The mucosa was somewhat atrophic and showed slight injection. On the postero-inferior surface of the stomach 3 cm. proximal to the pylorus was a polyp 2.5 cm. in diameter, attached to the gastric mucosa by a stalk-like pedicle 3 cm. long. The mucosa over the polyp was smooth with no visible necrosis or ulceration. Situated well above the polyp, and entirely independent from it, was an area of carcinoma 4 cm. in diameter, lying on the greater curvature and anterior surface of the stomach. It was firm and plaque-like, and its mucosal surface showed no gross ulceration. The peritoneal covering of the stomach had been invaded but there was no evidence of regional metastasis. No other polypi were visible in the resected specimen.

The microscopic diagnosis was scirrhous carcinoma of the stomach, fibrinous pedunculated gastric polyp, the mucosa about the base of the polyp showed no evidence of malignant change.

#### CONCLUSIONS

1. Pedunculated gastric tumors cannot be considered rare lesions.
2. From 10 to 20 per cent of benign gastric neoplasms develop pedicles and are capable of producing pyloric obstruction.
3. These pedunculated tumors show evidence of malignant degeneration in from 30 to 40 per cent of the cases.
4. Vague epigastric distress associated with intermittent attacks of pyloric obstruction represent the most common clinical features.
5. Ulceration, hemorrhage, obstruction and intussusception are the principal complications resultant from these lesions.
6. All cases of severe anemia of undetermined origin should be carefully studied to exclude the presence of a bleeding gastric polyp.

7. Proved cases of primary pernicious anemia should have the benefit of a thorough gastrointestinal study because of the frequent occurrence of polyps in this condition.

8. The final diagnosis rests in the hands of a competent radiologist.

9. Treatment should consist of partial gastrectomy, if this be feasible, to remove both the polyp and a wide area of the adjacent gastric wall.

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# THIRTY-NINE CASES OF APPENDICITIS IN A SINGLE FAMILY PEDIGREE

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AUTHORS have attributed infections of the vermiform appendix to an imposing array of diverse causes. Institutional diatheses of one sort or another and, indeed, by consulting the literature one may find evidence that such diverse

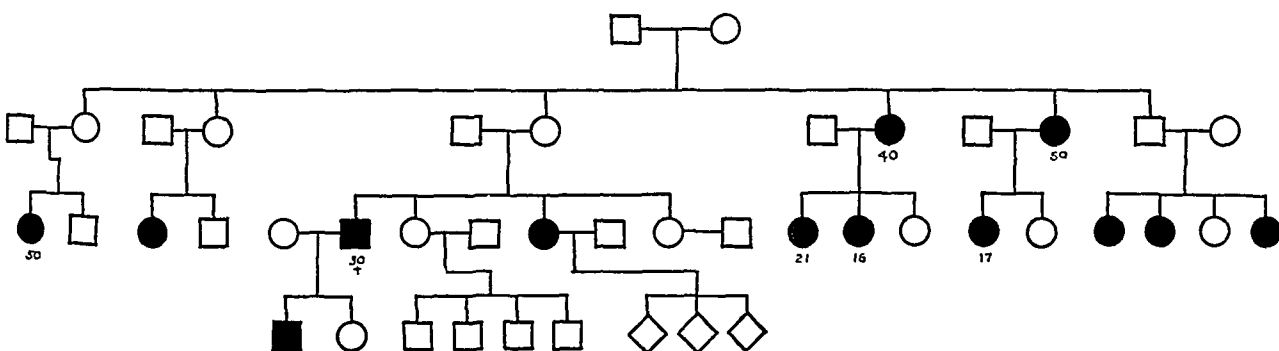


FIG. 1. Appendicitis. (Data from Caroli.)

Outstanding among these alleged causes may be named anatomic defects of position, of form, of size, of vascularization, of attachment and presence of Gerlach's semilunar valve. Other suspect conditions are arthritis with a tendency to produce both gallstones and appendicular fecaliths; a constitutional diathesis conducive to auto-infection; a tendency for infection to settle in the lymphoid tissues including the appendix, following such diseases as scarlet fever or scarlatina, grippe and typhoid fever. Nervous constitutions producing constipation as well as other digestive disorders are accused. Intestinal parasites are also incriminated.

It seems very probable that most of the alleged causes are responsible for many cases, and hence it appears unwise to search for a single etiologic factor common to all appendicitis infections.

Except in the event of infection resulting from the presence of intestinal parasites, the immediate physical causes of appendicular infection mentioned above might be determined by or contributed to con-

predisposing hereditary backgrounds do exist.

Caroli (quoted by Carnot<sup>1</sup>) described the family charted in Figure 1\* in which thirteen persons out of a total of thirty-six in four generations had appendicitis.

Okinczyc, quoted by Weinsaft,<sup>2</sup> describes the pedigrees of appendicitis shown in Figures 2, 3, and 4. The appendices of affected members of the family charted in Figure 3 were all between 15 and 17 cm. in length and were coiled.

Weinsaft reports the family charted in Figure 5, in which a daughter, a father and a paternal uncle were affected.

Colley<sup>3</sup> reports three small pedigrees whose affected members bore anatomic defects assumed to be the causes of infec-

<sup>1</sup> CARNOT, P. Les maladies digestives familiales. *Paris méd.*, 87: 288-299, 1933.

\* In our charts (except Fig. 1) squares represent males, circles represent females. Numerals placed beneath the symbols indicate age at time of attacks.

<sup>2</sup> WEINSAFT, P. Les appendicites familiales (remarques etiologiques). Univ. Paris Thesis 1933.

<sup>3</sup> COLLEY, F. Beiträge zur Klärung der Frage von der Erblichkeit der Entzündung der Blinddarmhanger. *Arch. f. Klin. Chir.*, 103: 177-208, 1914.



tion. In Figure 6 is represented a family the affected members of which lacked  $1\frac{1}{2}$  cm. of mesoappendix. However, contrary to

by Balogh.<sup>6</sup> We show his material in Figure 11.

Van Meter<sup>7</sup> suggests inherited suscepti-

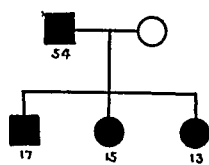


FIG. 2.

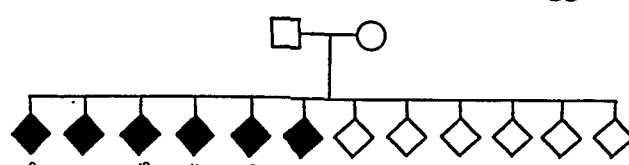


FIG. 3.

FIGS. 2, 3, AND 4. Appendicitis. The small coils in Figure 3 represent coiled appendices. (Data from Okinczyc.)

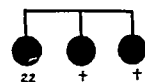


FIG. 4.

the statement of Weinsaft, this does not represent a Mendelian characteristic, just because there are 3 affected to 1 normal in the third generation. Indeed, this anatomic peculiarity appears to be due to a single dominant gene, in which case the expectation is equal numbers of affected and normals. The 3 to 1 ratio obtained in this isolated instance was due to the probable error of random sampling. In Figure 7 are charted a father and a daughter in which the artery of the

bility to appendicular infections dependent upon inherited anatomic peculiarities. In Figure 12 we show Van Meter's pedigree of large angulated appendices. In Figure 13 we show Van Meter's data for coiled appendices.

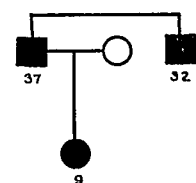


FIG. 5. Appendicitis. (Data from Weinsaft.)

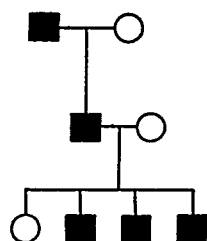


FIG. 6. Missing meso. (Data from Colley.)

mesenteriole was very small and in which the vein was almost obliterated. In Figure 8 there was found at operation, an appendix fused to an ovarian cyst in a mother and also in her daughter.

Alvarez<sup>4</sup> supports the lithiasis theory with a pedigree shown in Figure 9.

Leckie<sup>5</sup> reported the pedigree of appendicitis which we have charted in Figure 10.

Short, thick appendices having wide openings into the cecum and subject to clogging with feces have been described

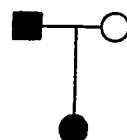


FIG. 7.

FIG. 7. Small veins. (Data from Colley.)

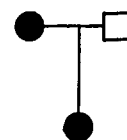


FIG. 8.

FIG. 8. Appendix adhered to ovarian cyst. (Data from Colley.)

Magruder<sup>8</sup> describes four families in which more than one member had appendicitis. The largest pedigree (Fig. 14) shows twelve affected persons. Another family

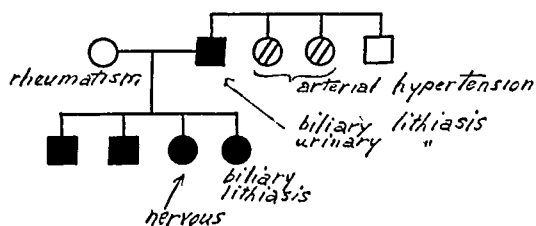


FIG. 9. Nervousness and lithiasis. (Data from Alvarez.)

shown in Figure 15 has five affected members, while the other two pedigrees (Figs. 16 and 17) have merely two affected members.

<sup>4</sup> ALVAREZ, Hypertension and appendicitis in eight members of one family. *M. Clin. North America*, 2: 1435-1447, May 1928.

<sup>5</sup> LECKIE, G. G. Interesting family history of appendicitis. *Canad. M. A. J.*, 36: 287, 1937.

<sup>6</sup> BALOGH, E. Beitrag zur Lehre von der Erkrankung an appendicitis. *Deutsche Ztschr. f. Chir.*, 245: 325-328, 1935.

<sup>7</sup> VAN METER, S. D. Hereditary appendicitis. *Colorado Med.*, 17: 241-244, 1920.

<sup>8</sup> MAGRUDER, E. M. Hereditary predisposition to appendicitis. *Virginia M. Monthly*, 45: 309, 1919.

In 1922 Cignozzi<sup>9</sup> summarized his findings in 500 cases of appendicitis within a circumscribed geographic area. He felt that

dominant unit-characters. Such characters are: (1) missing section of mesoappendix; and (2) variations which may be described

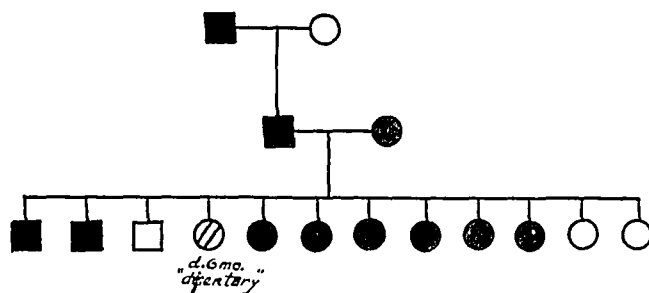


FIG. 10. Appendicitis. (Data from Leckie.)

when the appendix was situated high, due to incomplete rotation of the colon, attacks of appendicitis were more acute. Among these 500 cases fifty were found to be familial.

The authors have found several families affected by appendicitis. In Figure 18 is charted a family having five affected

as coiled, short, long and retrocecal. It has been assumed that these bizarre morphologic forms produce appendicitis, but no one has operated on normal members of the same families to prove whether or not these individuals may bear these same anatomic abnormalities throughout life with impunity.

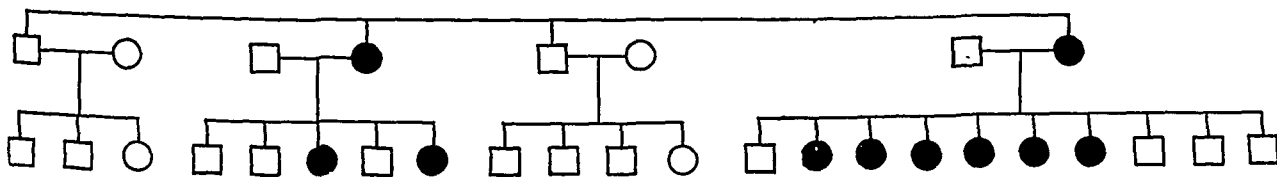


FIG. 11. Short thick appendices with wide openings. (Data from Balogh.)

members, all operated on. Figure 19 describes a family having ten members that were operated for recurrent appendicitis. The "X" marks indicate burst appendices at the time of operation. The affected persons in this family all had retrocecal appendices.

That other disturbances of the digestive tract such as tonsillitis, gall-bladder disease, and ulcerative colitis are occasionally present is not to be denied. It may conceivably be due to chance that some of these accompanying conditions strike persons suffering from appendicitis, and yet

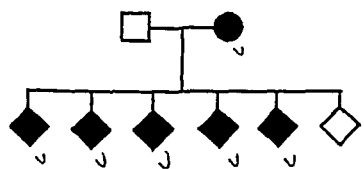


FIG. 12. Large angulated appendices. (Data from Van Meter.)

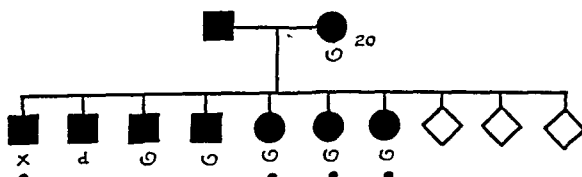


FIG. 13. Coiled appendices. (Data from Van Meter.)

Some of the pedigrees we have reviewed are so meager as to carry little weight, whereas others are quite convincing evidence that peculiarities or anomalies of the appendix are inherited as simple

some cases are highly suggestive of a common cause.

In reviewing the records appearing in the literature, one is constrained to wonder concerning the dietary habits of the families described. Only too often cases are recorded from hearsay or from the word of

<sup>9</sup> CIGNOZZI, O. Le appendiciti familiari. *Policlinico sez. Chir.*, 29: 585-590, 1922.

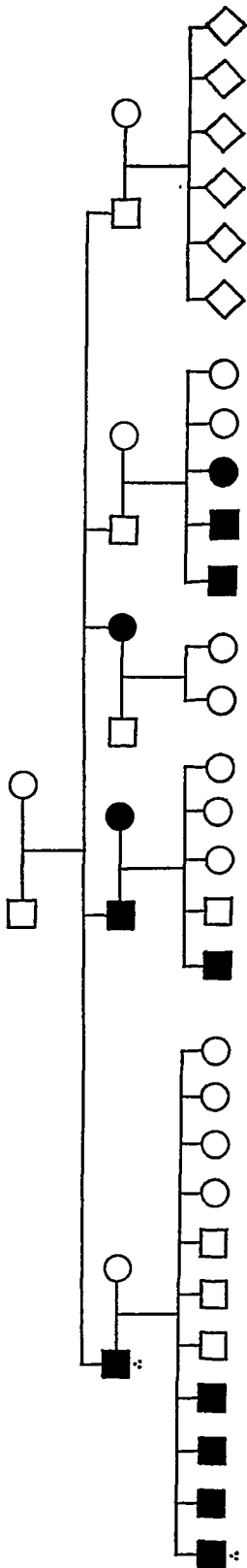


FIG. 14. Appendicitis. (Data from Magruder.)

a single patient. Had it been possible to follow the leads of some of these cases appearing in the literature, it seems probable that much more extensive pedigrees would have come to light, providing that the several diatheses for appendicitis are genetic and unit-dominants in nature, as they appear to be in the cases reported.

A pedigree of appendicitis which we now present is by far the most extensive one yet placed upon record as will be evident from an examination of Figure 20. Intimate acquaintance with this expanded network of relationships allows us to answer a number of criticisms which logically might be brought against the collection of appendicitis pedigrees from a genetic standpoint. The households represented are quite comfortably situated. The stock is primarily old Yankee. The intelligence and capability is high. Knowledge of balanced diets is complete. Nervous disorders are uncommon. Except in two cases, described as chronic by the surgeon, there has been no tendency to remove the appendix as a preventive measure, although tonsils have been excised as a matter of course. Hence the possible correlation between tonsillitis and appendicitis cannot be studied in this pedigree.

There have been some cousin marriages in the past in this family. The pedigree chart is a bit complicated due to the marriages of two brothers ( $F_{10}$  and  $F_{20}$ ) to two sisters ( $F_{11}$  and  $F_{21}$ ). This fact has necessitated two long parallel lines, each connecting a set of siblings.

Viewing the pedigree as a whole, one will note immediately that the cases are not distributed at random, as might be expected if no hereditary diathesis were present. On the contrary, in the upper section of the pedigree the cases occur sporadically in 6.5 per cent of the population, whereas in the lower section they occur in 35 per cent, or more than five times as frequently. This makes it apparent that some sort of hereditary diathesis is being transmitted in the lower portion of the pedigree.

The average age at the time of attacks shows a definite anticipation, the average ages being 52.5 years for the  $F_1$ ; 32.3 years

gesting a unit-dominant. These data, with suggestions both of dominance and recessivity, cannot be reconciled with each other

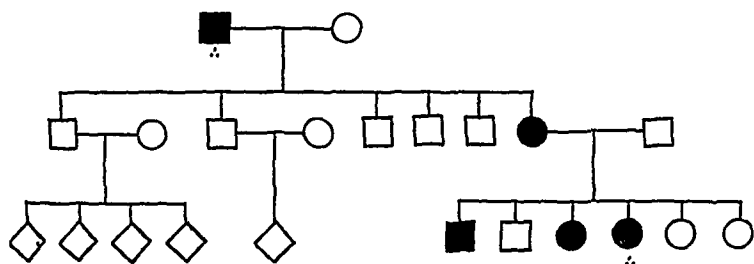


FIG. 15.

FIGS. 15, 16 AND 17. Appendicitis. (Data from Magruder.)

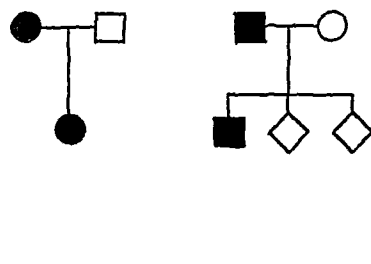


FIG. 16.

FIG. 17.

for the  $F_2$ , 13.4 years for the  $F_3$ . The one affected child in the  $F_4$  was 7 years of age. It must be said, however, that  $F_1$  11, although she had bouts of appendicitis for several years, was not operated on until the terminal attack from which she died at the age of 66.

If we try to single out particular types of matings and apply Mendelian formulae, the data do not make sense.

There are sixteen affected males and twenty-three affected females, indicating that no male sex linkage exists. Eight matings between normals produced nineteen normals and thirteen affected, which

and the best we can say is that appendicitis tendencies are inherited in this family but in an irregular fashion.

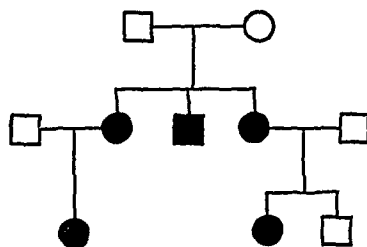


FIG. 18. Appendicitis.

If we study the twenty-one hospital records which we have been able to obtain, we find such diverse accompanying

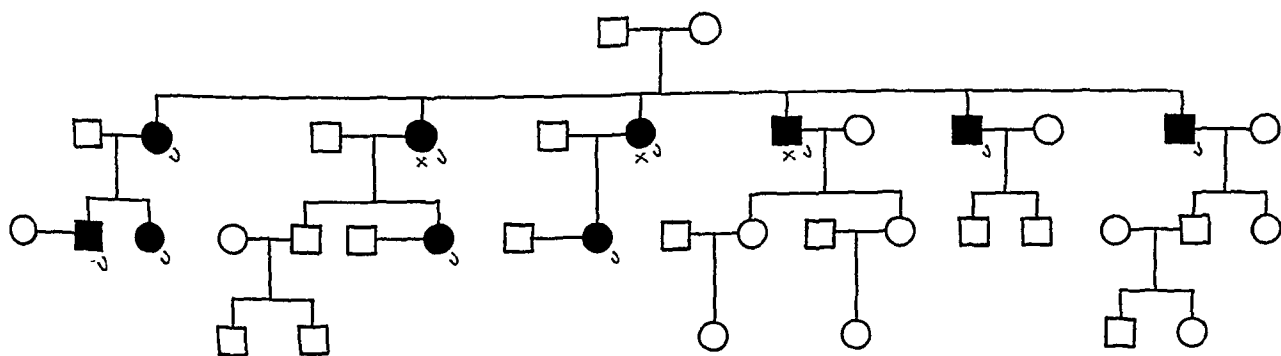


FIG. 19. Retrocecal appendices.

is a wide deviation from the recessive Mendelian 3:1 ratio. Five families have one affected parent (not counting the last generation in which the children are still young). These families have eight normals and eleven affected, suggesting a unit-dominant.

In three families both parents have had appendicitis and in these, three children are normal and six are affected, also sug-

or predisposing factors as gall-bladder disease, coiled appendices, long appendices, retrocecal appendices.

If we examine the portion of the pedigree where appendicitis is most concentrated we find that the complex consists of the appendicitis family of male  $F_2$  27, who married into the appendicitis family of female  $F_2$  28 (inclosed in dash line).  $F_2$  27, his two sisters  $F_2$  23 and  $F_2$  41, as well as

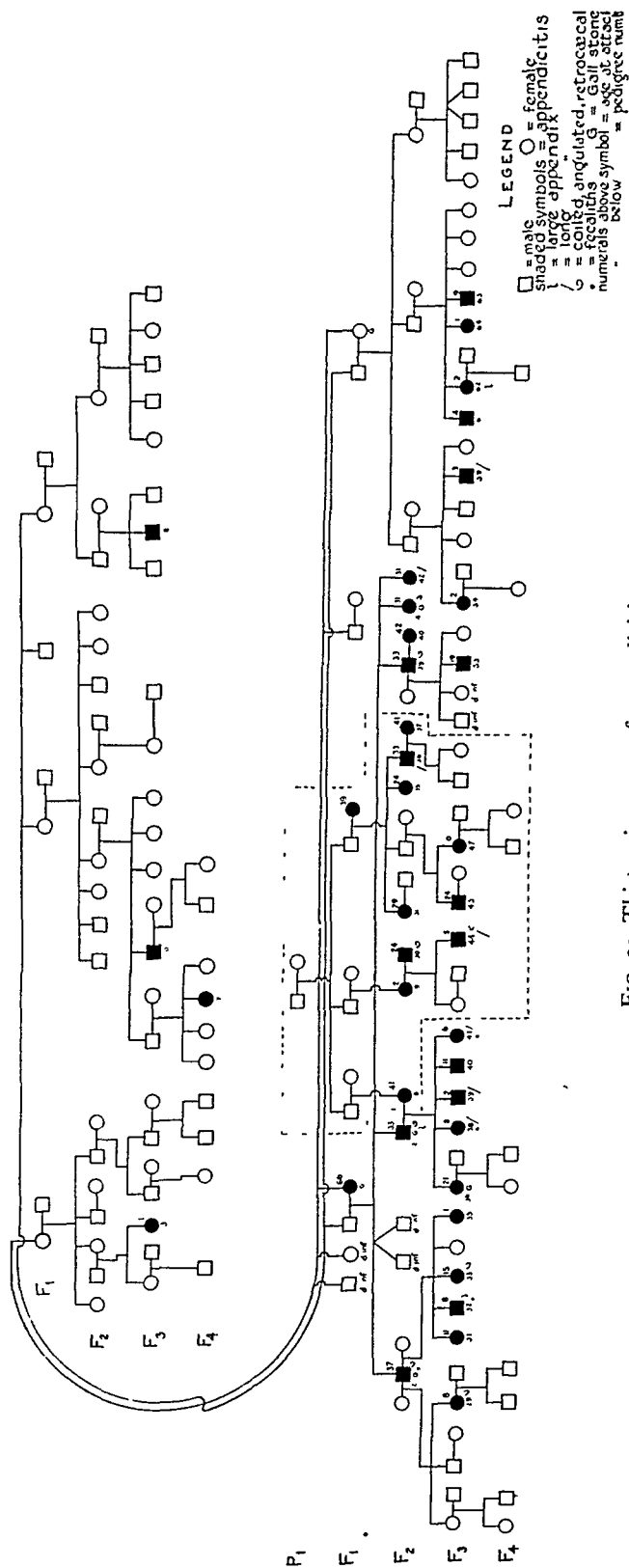


FIG. 20. Thirty-nine cases of appendicitis.

his mother and a maternal aunt, all had gallstones. In his wife's family no gallstones are recorded. His daughter ( $F_3$  36) had gall-bladder trouble following her first pregnancy but she had no gall-bladder operation.

$F_2$  27 and three of his siblings ( $F_2$  23, 39, 41) had coiled, kinked, or retrocecal appendices. His appendix, as described in the operation report, was large, and that of his sister  $F_2$  42 was very long.  $F_2$  27 apparently transmitted his "large" appendix to his three children ( $F_3$  38, 39, 41) whose appendices were "elongated," "10 inches long," and "8 inches long" respectively.  $F_2$  23 (the brother of  $F_2$  27) who had a "sharp angle or twist" had, by two wives, five affected children ( $F_3$  29, 31, 32, 33, 35), three of whom had appendices described as "angulated," "retrocecal," and "moderately kinked on itself."  $F_2$  23, his child ( $F_3$  32), and his two nieces ( $F_3$  38, 41) all had fecaliths. The relatives,  $F_3$  59 and  $F_3$  62, had "long" and "large" appendices respectively. Thus, in this one family we have the predisposing factors of lithiasis, gallstones, long or large appendices, and bent, coiled or retrocecal appendices appearing as hereditary characters. (It is to be understood, however, that kinking or coiling of the appendix may frequently be acquired rather than hereditary.)

In the family of  $F_2$  28 a father ( $F_2$  30) and his son ( $F_3$  44) have coiled appendices. Long appendices are recorded for  $F_2$  36 and  $F_3$  44.

Those findings are quite in contrast to our pedigree shown in Figure 19 in which the one predisposing factor of retrocecal form of the appendix is inherited as a simple, dominant unit-character, once appendicitis has appeared. To us it seems highly improbable that all the predisposing factors shown in Figure 20 could be different manifestations of one hereditary cause.

We are forced to conclude in view of all the facts recorded in the literature and from our own studies that there are a number of hereditary factors predisposing to appendicitis (some of which factors are inherited as irregular dominants), and that the genes for several of these predisposing physical factors, as shown in Figure 20, are concentrated in the germ plasm of  $F_1$  11 and her descendants, one of whom ( $F_2$  27) married into the appendicitis family of  $F_2$  28.

#### SUMMARY

A review of the literature shows that a number of diverse hereditary constitutions are probably conducive to appendicitis. We present a pedigree containing thirty-nine individuals who have suffered from appendicitis. The tendency to appendicitis is hereditary in this pedigree, and seems to involve the transmission of several different types of predisposition.

The authors are deeply indebted to a number of hospitals and physicians who so kindly provided us with case histories and especially to Dr. John E. Ruisi of Westerly, R. I., who operated upon several of the patients and who has greatly assisted us with the literature.



# A CLASSIFICATION OF FOREARM FRACTURES NEAR THE WRIST

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THE subject of this discussion is an anatomic and roentgenologic study of fractures of the forearm bones near the wrist understood in any department of knowledge; and comprehension is a prerequisite for intelligent memory and for rational



FIG. 1. Posterior view of the hand in dorsal flexion and palm down position.

the wrist, presented for the purpose of introducing a classification, with a system of internal measurement derived from anatomic landmarks. The classification, which has been observed and applied to cases for the past five years, and used for teaching purposes for the last two, is submitted for critical review and confirmation by other workers interested in these fractures.

The late A. P. C. Ashhurst<sup>1</sup> wrote: "It is perhaps unnecessary to argue the desirability of classification; for without classification, the relation of one lesion to another can be neither remembered nor



FIG. 2. Palmaris longus tendon retracted with a portion of the palmar fascia attached.

diagnosis and treatment." These classic words render further discussion of the value of classification superfluous, except to note that classification is not a simple listing of different types of lesions, in this case, fractures. Such a listing is a catalog but not a classification. A true classification should demonstrate some fundamental relation of one lesion to every other lesion.

The primary observation of this paper is that in suprazyoid fractures of the radius, the distance from the center of the ulnar

styloid base to the second carpometacarpal articulation equals the distance from the ulnar styloid base to the point where the fracture line joins the lateral surface of the radius. The exceptions are few. This observation is grounded in the three following concepts of applied anatomy, not greatly emphasized heretofore. The first two were mentioned in the December, 1937 issue of this journal.<sup>2</sup>

1. The proximal row of carpal bones move as a unit in transmitting force from the hand to the radius.

2. The distal row of carpal bones, except the greater multangular, combined with the four medial metacarpals, forms the central unit of the hand, in which any force entering the radius from the hand originates.

3. The recognition of the fact that the distal end of the ulna lags behind the radius in growth from childhood to adult life.

The problem toward which this work is directed is twofold:

1. When an individual falls on the hand, why does the site of fracture move distally in the radius as age increases, until adult life is reached?

2. What is the precise level of supra-styloid (Colles') fracture?

In Colles' original description, he placed the fracture line  $1\frac{1}{2}$  inches above the carpal extremity of the radius. Since that time, there has been a difference of opinion regarding the exact level of the fracture line. Eliason and his associates<sup>3</sup> refer to the confusion existing and place the fracture  $\frac{1}{2}$  to  $\frac{3}{4}$  inch above the joint surface of the radius, and designate the lesion as "supra-styloid." Any review of the literature will show that attempts at the precise definition of this lesion, not excepting Colles' original description, have all been expressed in terms of external linear measurement, i.e., not in relation to regional anatomic landmarks.

The observations presented here are made in the usual anteroposterior films of the wrist in 180 degrees extension. The hand may be in midposition, radial or

ulnar deviation. Under these conditions, one point of a compass is placed in the middle of the base of the ulnar styloid, and

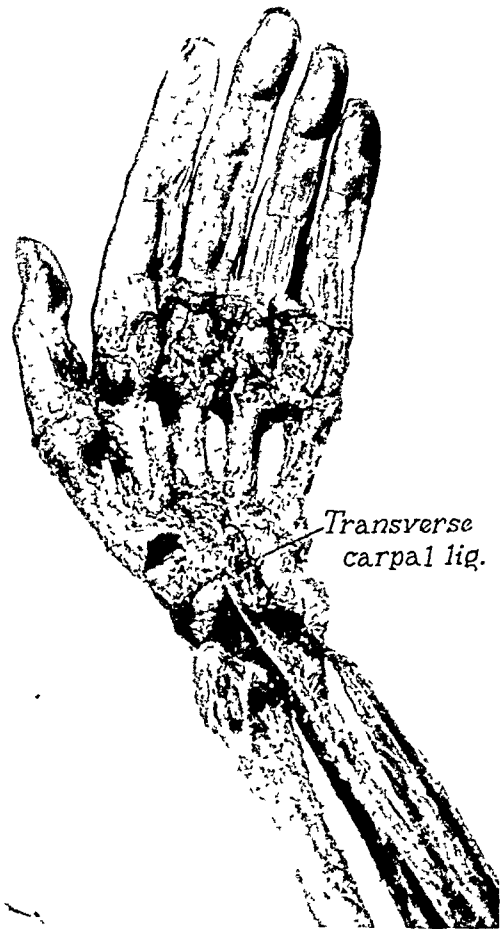


FIG. 3. Anterior portion of the transverse carpal ligament has been removed.

the other in the middle of the articulation between the os capitate and the proximal end of the second metacarpal. (Figs. 12 and 13.) With this distance as a radius and with the point on the ulnar styloid as a center, a line is drawn proximally, forming the arc of a circle which crosses the radius and ulna. This line will be found to intersect the fracture line where it meets the lateral border of the radius. (Plates I, II and III.) The circle with the term "circle test" is used in what follows, merely as a simple device to demonstrate that the middle of the proximal end of the central unit of the hand is the same distance from the



ulnar styloid, as the ulnar styloid is from the point on the radius where the fracture line joins the lateral border of the bone.

(b) An overlooked greenstick fracture in the lower end of the ulna, with resultant bending of the distal end of the ulna toward

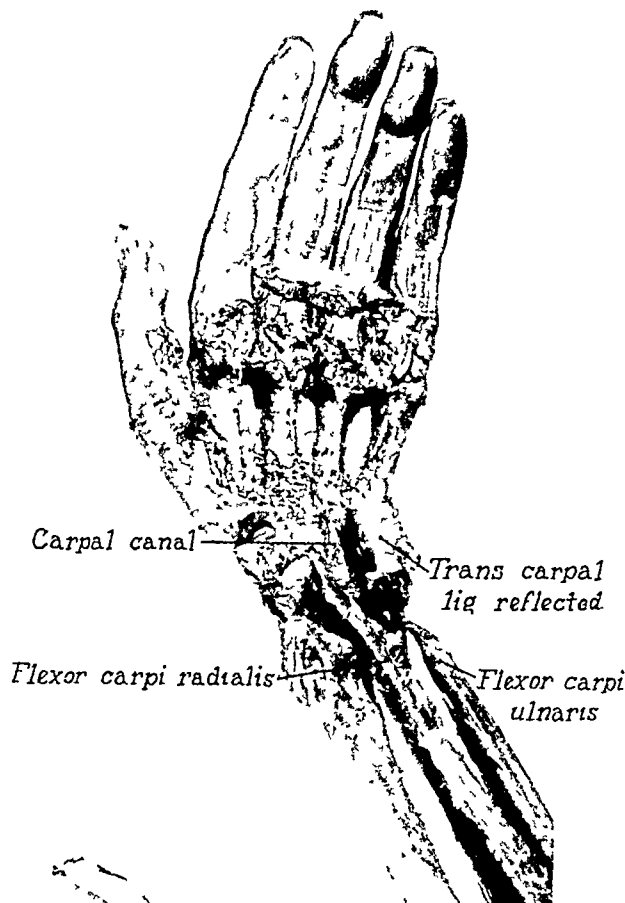


FIG. 4 Transverse carpal ligament severed from its attachment on the radial side.

Sources of error in the use of this type of measurement are:

1. The film should be a true antero-posterior film, i.e., under optimum conditions the full width of the distal radio-ulnar articulation should be shown. After one has applied the above maneuver to a hundred or more fractures of all ages in this region, and satisfied himself of the validity of the test, a moderate amount of distortion is readily discounted.

2. Any condition which changes the normal distance from the base of the ulnar styloid to the second carpometacarpal joint:

(a) A shortening of the carpus, such as that seen in severe arthritis with destruction of the cartilage.

the radius. This is especially common in very young children.

(c) Fracture with displacement of the entire lower end of the ulna.

(d) An abnormally long or short ulna, or ulnar styloid.

Unfortunately, the simplicity and ease with which the test is applied may cause it to be regarded as an act of prestidigitation. In an effort to dispel this attitude, certain questions are anticipated.

1. *Of what use is the circle test?*

(a) It differentiates the typical fracture, sustained in a fall to the standing level, from the atypical fracture. The typical fracture is on the line or slightly distal to it, but is not proximal to it.

(b) It demonstrates that the supra-styloid fracture in children is governed by the same mechanics which operate in the production of the adult (Colles') type.

(c) It directs attention to growth changes in the distal end of the radius and ulna, identifying slight variations from the normal.

(d) It serves as a system of internal measurement based on anatomic landmarks, rather than on linear measurement.

(e) It defines supra-styloid (Colles') fracture of the radius as a double rotation (lateral and dorsal) fracture of the radius, in which the leverage effects of the central unit of the hand seem to be demonstrated.

2. *Why was the middle of the base of the ulnar styloid selected as the center of rotation?*

The ulna is more largely the continuation bone of the humerus, since it articulates with the humerus in a manner which permits motion in only one plane; whereas the radius not only moves in this same plane, but is permitted rotation on its long axis through the head and neck, while distal to the neck it rotates about the distal portion of the ulna. The distal ends of the radius and ulna are parallel members, firmly bound together by the strong ligaments of the distal radio-ulnar articulation, as well as by the interosseous membrane and the ligaments from the ulnar styloid to the carpus. The medial ligaments of the wrist are attached to the tip and as far proximally as the base of the ulnar styloid, while the triangular fibrocartilage is attached to its base.

In such an arrangement, if force is applied to the radius in its long axis from distally, and fracture of the distal end occurs, the fractured portion which is bound to the lower end of the ulna must rotate about a point in the lower end of the ulna as a center. If one wishes to state the proposition differently and show that the force comes from above or proximally, the result is the same. The lower end of the radius meets resistance coming through the carpus and is stopped and held, while the lower end of the ulna which does not enter

into the wrist joint and which receives very little if any direct force, is carried on and has a tendency to ride distally past the

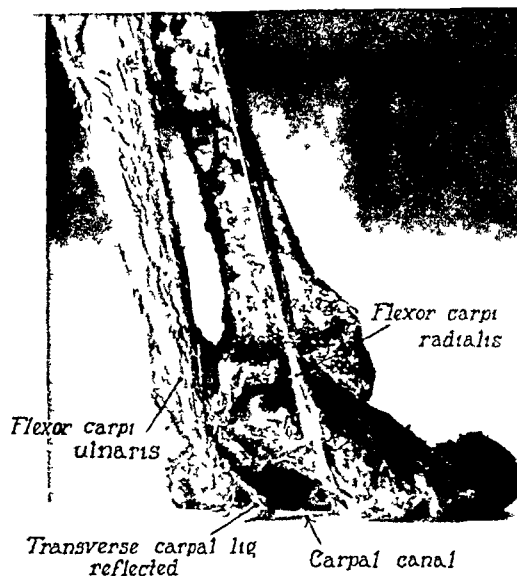


FIG. 5 Palm down position, showing the carpal arch which sustains the weight of the body in a fall on the hand

lower end of the radius. The clinical proof of this lateral rotation of the distal fragment is seen in the lateral tilt of the fragment, together with the invariable displacement of the ulnar styloid fragment, when it is fractured, toward the carpus.

3. *Why was a point chosen in the middle of the second carpo-metacarpal articulation?*

The selection of this point was not arbitrary. It rests on a conception of the functional anatomy of the hand and carpus, described in 1933,<sup>4</sup> and again more recently.<sup>2</sup> Even a cursory study of the anatomy of the distal end of the radius and ulna will show that the hand and carpus are rotated away from the ulnar styloid as a center, in a fall on the hand. But the task of demonstrating the use of the hand as a lever in guiding and disseminating force to the radius was found to be difficult and puzzling. It was learned that the proximal row of carpal bones act as a unit, moving as one piece and acting as an adjustable disc for the transmission of force from the remainder of the hand to the radius. (Figs. 12-15.) This conception of the function of the proximal row bones is substantiated by

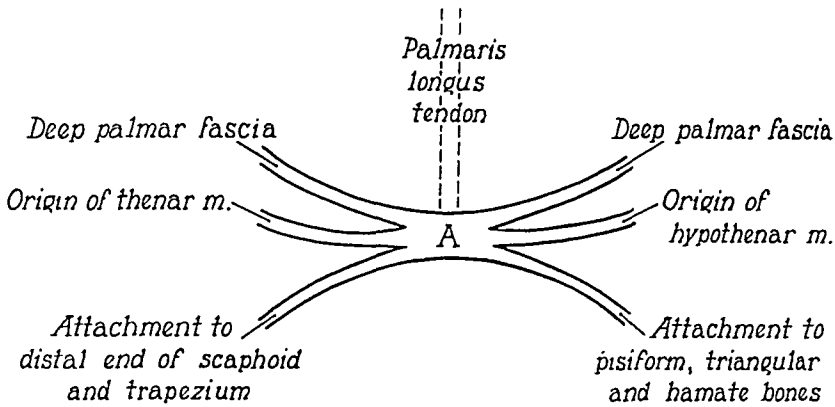


FIG. 6. The fusion of the central portion of the palmar fascia (aponeurosis) with the trans. carp. lig., forms a structure of great clinical importance in any study of transmission of force through the hand, either to the carpal bones or to the radius. From a clinical viewpoint, it is a unified structure and is here labelled 'A,' the central tendon of the hand. The texts with which I am familiar do not properly interpret the functional significance of this central tendon. Its clinical importance is actually obscured when studied under classical anatomical subdivisions. It is quite apparent that any force received through the palm of the hand or through the hand used as a fist, is sustained in whole or in part by the central tendon.

The thick middle portion of the palmar fascia has two layers; an anterior whose fibers are longitudinal, and a deeper layer composed of transverse fibers which blend with the trans. carp. lig. The palmaris longus, an exceedingly variable muscle which is absent in 10-20 per cent of specimens, is a tensor not only of the palmar fascia but also of the entire structure of the central tendon. As seen in cross section, the central tendon is six tailed in three planes, having the palmar fascia in the anterior plane; giving origin to the thenar and hypothenar muscles in the middle plane; and finding attachment to the anterior surfaces of the bones which form the carpal canal, in a deeper and more dorsal plane.

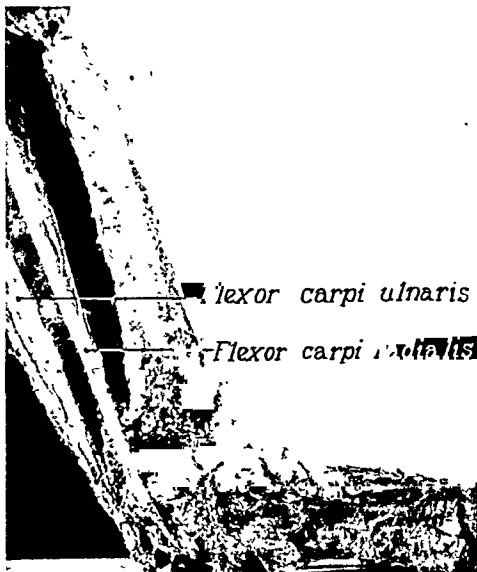


FIG. 7. Lateral view, dorsal flexion.

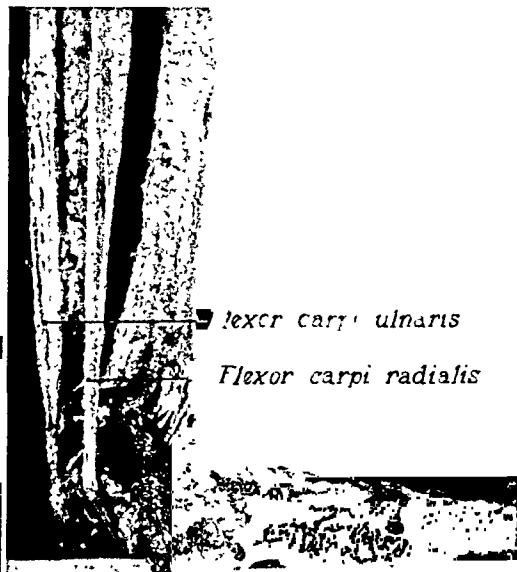


FIG. 8. Lateral view, extreme dorsal flexion.

the fact that none of these bones has muscles inserting on it. They are under control of the flexors carpi ulnaris and

It should also be recognized that the distal carpal row bones, except the greater multangular, together with the four medial

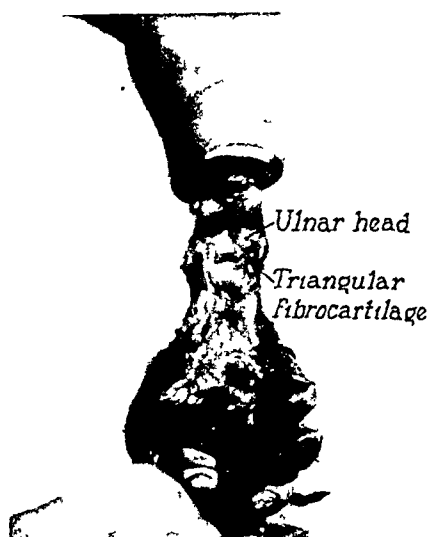


FIG. 9. A newborn wrist, anterior view.

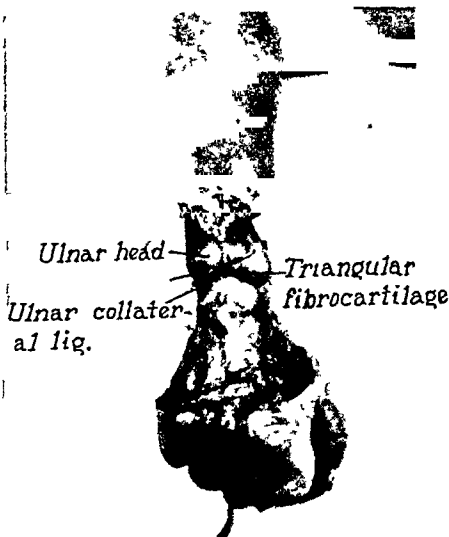


FIG. 10. A newborn wrist, posterior view.

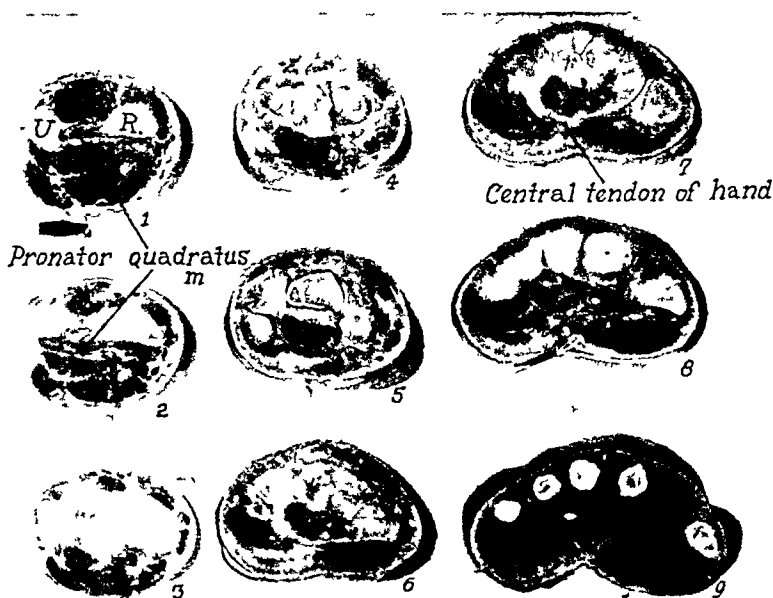


FIG. 11. Transverse sections through the wrist.

radialis through the connection with these muscles at either end of the proximal row, at the distal end of the scaphoid and through the sesamoid pisiform to the triangular. The extensor tendons on the dorsum of the wrist, both for the wrist and for the fingers, have no insertion on either the proximal or the distal row of carpal bones.

metacarpals, act as the central unit of the hand, between whose individual members there is scant movement. All the extensor tendons of the wrist and fingers insert in this central unit, except those to the thumb which go to the first metacarpal or distal to it. The carpal bones form an arch subtended by the strong transverse carpal ligament (Figs. 2-8, 11, 14) and it is this arch,

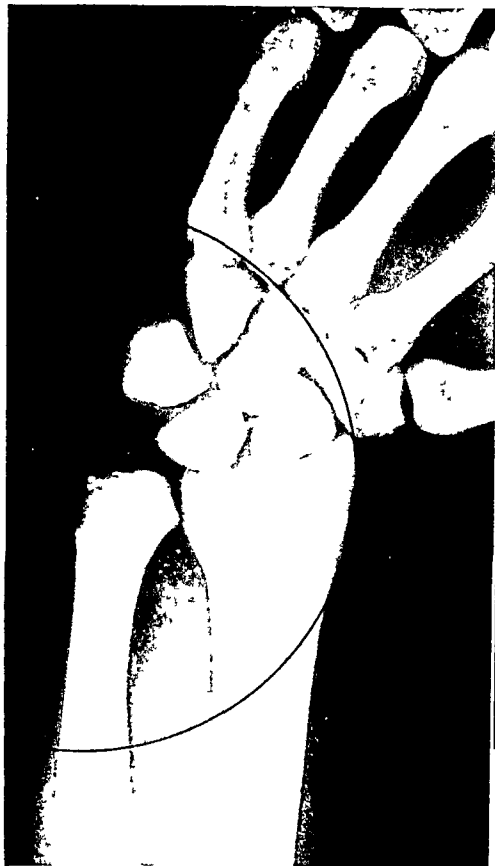


FIG. 12. Extreme radial deviation with circle applied. The third metacarpal, os capitate and semilunar bones are in line. The distal radio-ulnar articulation is shown in a direct a-p view. The tip of the radial styloid is at the midcarpal joint line. Note that the lateral styloid convexity of the radius is poorly developed.



FIG. 13. Extreme ulnar deviation with circle applied. The os capitate and the third metacarpal are in line with each other but not with the semilunar. There is some rotation in taking the film in that a clear view of the cartilaginous area of the distal radio-ulnar articulation is obscured. The pisiform is slightly off the triangular in a proximal direction.



FIG. 14. Lateral view, dorsal flexion. The subject placed all the weight possible on this hand, short of losing his balance, when the film was taken. The dorsal lip of the radius overrides the proximal row of carpal bones. Note that the bones of the distal carpal row and the metacarpals are in the same horizontal plane.

with the central tendon of the hand, which sustains the full body weight in a fall on the hand. With these facts in mind, the puzzle

4. *Is it a coincidence that the circle formed by a radius whose length is equal to the distance between the ulnar styloid base and the*



FIG. 15. Lateral view, anterior flexion.

zling action and distribution of forces in this region were somewhat clarified. After the proximal carpal row was recognized as an adjustable bony-cartilaginous plate, attention was focused on the central unit of the hand, consisting of the four medial metacarpals and the three medial carpal bones of the distal row.

Considerable interest was directed toward the os capitate from the beginning of this study, not only because it is the largest bone in the carpus, but also because it is the first bone to appear in the x-ray, casting a shadow at the age of six or eight months. It was assumed that of all the carpal bones, the capitate was subjected to maximal force from early life onward. Dissecting room studies also showed that the line drawn through the articulating surface between the os capitate and the second metacarpal, approximately bisected the chord which subtends the arc formed by the proximal surface of the distal carpal row. In other words, on the cadaver, this articulation represents the approximate midpoint of the proximal end of the central unit of the hand. The x-ray anatomy here, in the anteroposterior view, is very deceptive owing to the depth of the arch formed by the carpal bones. (Fig. 5.)

*middle of the second carpometacarpal joint, coincides with the lateral convexity of the adult radius?*

Early in this study, when such a distance was first used, it was so regarded. Obviously any fracture line which comes through to the lateral surface of the radius must be intercepted by the circle. Interest was heightened when films prepared with the hand in complete ulnar or radial deviation, showed that the second carpometacarpal articulation remained on the circle, in any position of ulnar or radial deviation or in midposition. (Figs. 12 and 13.) The matter rested here for a few months, when the interesting observation was made that in children, the circle passed through the line of fracture on the lateral surface of the radius with few exceptions, although it did not coincide with the lateral surface of the bone, but swung widely lateral to it. (Plate 1, Figs. 1, 2, 3, 5 and 6.) Before an ulnar styloid is formed, the compass is placed over the medial distal end of the ulna, where the ulnar styloid will later appear.

5. *How does the circle test for fractures of the radius hold true in both adult and childhood fractures, when the adult type is  $\frac{1}{2}$  to  $\frac{3}{4}$  of an inch from the wrist joint, and the*

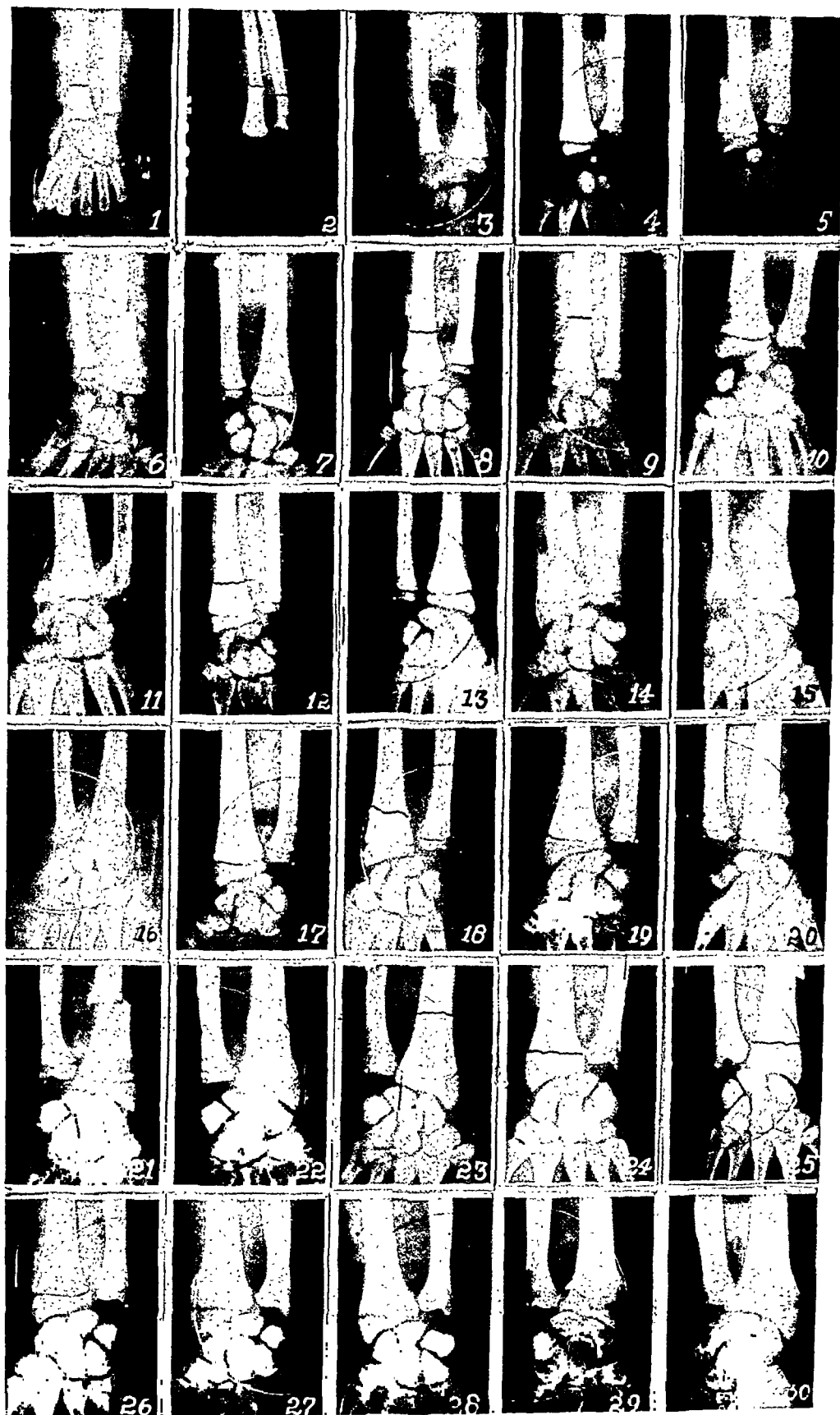


PLATE I. For legend see opposite page.

childhood type is 1 to 1½ inches from the joint?

The answer to this consists of one of the three main points supporting this classification. There is a simple anatomic fact which serves to place fractures in all age groups in this region in the same mechanical category. It is the observation that the distal end of the ulna lags behind that of the radius in growth, so that in the young child the distal end of the ulna is approximately ¼ to ½ inch proximal to the lower end of the radius. As age increases, the distal ulnar end tends to gain on the radius, until when growth is completed, it has reached its adult position. (Plate 1, Figs.

1-24.) The situation is reversed at the elbow where the growth of the ulna exceeds that of the radius. (Plate III, Fig. 72.)

6. *Is it true that the common site of adult fracture, where the cancellous bone of the distal end of the radius joins the cortical bone of the shaft, is a weak area in the radius?*

This area has been spoken of and taught as a zone of weakness in the bone, and it may be true, although no incontrovertible evidence was found in favor of or against this view. However, it is a fact, that at the level of the usual adult fracture line, the bone also changes its shape. The question then arose: Does the fracture line occur in its usual site, because of the change in

#### PLATE I.

- No. 1. M. S., age 20 months. Greenstick subperiosteal fracture of radius, distal third.
- No. 2. F. K., age 20 months. Fracture of both bones in distal third.
- No. 3. J. K., age 5. Fracture of both bones, distal third.
- No. 4. J. K., age 7. Questionable epiphyseal separation. The distal end of the ulna is bent in toward the radius, causing the circle to miss the epiphyseal line.
- No. 5. J. H., age 8. Fracture in distal third of both bones.
- No. 6. B. S., age 8. Fracture in distal third of both bones.
- No. 7. J. G., age 9. Epiphyseal separation of distal epiphysis of radius.
- No. 8. W. W., age 9. Greenstick fracture in distal third of radius.
- No. 9. A. H., age 10. Greenstick fracture in distal third of radius.
- No. 10. G. R., age 11. Epiphyseal separation, distal radial epiphysis with fracture of distal end of ulna.
- No. 11. G. R., age 11. Same patient as No. 10 but before reduction.
- No. 12. G. G., age 11. Greenstick fracture distal third of radius. Circle misses the fracture line by almost a centimeter.
- No. 13. J. M., age 12. Epiphyseal separation distal radial epiphysis. Circle misses by about 0.5 cm.
- No. 14. H. B., age 13. Fracture of both bones in distal third.
- No. 15. D. Y., age 13. Fracture of both bones in distal third with chip fracture of ulnar styloid.
- No. 16. L. Z., age 13. Chip fracture of posterior border of the diaphysis, with probable reduced epiphyseal separation. Note how the ulna is bent in toward the radius. The circle misses by 0.5 cm.
- No. 17. S. B., age 13. Chip fracture of posterior border of the diaphysis with epiphyseal separation and fracture of the ulnar styloid. Circle misses.
- No. 18. H. W., age 13. Greenstick fracture in distal third of radius.
- No. 19. R. M., age 13. Fracture of both bones in the distal third.
- No. 20. W. G., age 14. Fracture of distal radial third with fracture of ulnar styloid. Circle misses slightly.
- No. 21. N. S., age 15. Fracture of distal radial third with fracture of ulnar styloid.
- No. 22. R. A., age 15. Fracture of distal radial third with fracture of ulnar styloid.
- No. 23. J. C., age 16. Fracture of distal radial third.
- No. 24. G. F., age 21. Subperiosteal fracture distal radial third. Circle misses slightly. Notice the distortion produced in taking the film, so that one sees the radial surface of the distal radio-ulnar articulation.
- No. 25. M. C., age 17. Fracture distal end of radius with fracture of ulnar styloid. Circle intercepts fracture line. Epiphysis is closed, and distal end of ulna is somewhat atypical.
- No. 26. F. K., age 14. Epiphyseal separation of the radius with fracture of the radial styloid.
- No. 27. W. P., age 33. Fracture of radial styloid. No displacement. Cranking a car.
- No. 28. W. D., age 25. Fracture of radial styloid. No displacement. Cranking a car.
- No. 29. F. K., age 37. A comminuted fracture of distal end of radius. No displacement. Cranking a car.
- No. 30. F. B., age 30. Fracture of radial styloid. No displacement. Cranking a car.



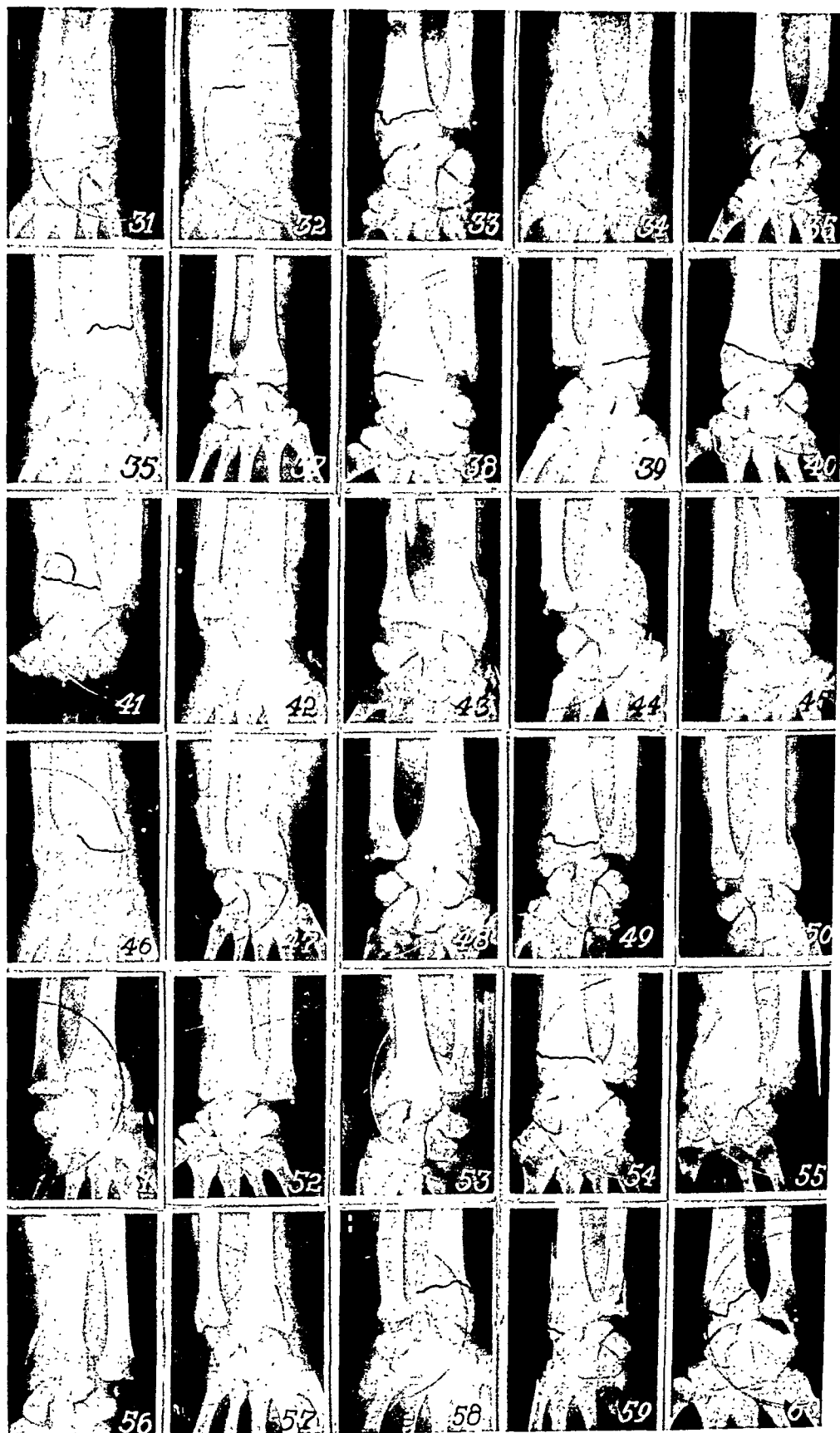


PLATE II. For legend see opposite page.

character or contour, or both; or is this an area in which the full effects of leverage forces generated in the hand are seen? The latter view was held to be the correct one. Cancellous bone is probably as strong as cortical bone, in its proper rôle, but its function is different. It seems to act as an

instrument for condensing or focusing forces into the smaller diameter occupied by cortical bone. Jansen<sup>5</sup> wrote: "Summing up what previous chapters have taught concerning the structure of cancellous tissue, we come to the following conception: the lines along which pressure stresses

## PLATE II.

- No. 31. W. H., age 9. Fracture of both bones in the distal third. Cranking a car. Atypical.
- No. 32. E. W., age 13. Fracture of both bones in the distal third. Cranking a car. Circle passes through fracture line.
- No. 33. H. B., age 35. Fracture of distal end of radius with ulnar styloid. Cranking a car.
- No. 34. J. B., age 44. Comminuted fracture of distal end of radius with ulnar styloid fracture. Cranking a car.
- No. 35. S. P., age 24. Fracture in distal end of radius with ulnar styloid fracture. Cranking a car.
- No. 36. N. B., age 18. Fracture in the distal end of radius with ulnar styloid fracture. Cranking a car.
- No. 37. D. P., age 42. Fracture of radial styloid. No displacement. Fell down stairs. Resembles a Chauffeur's.
- No. 38. H. B., age 32. Fracture of radial styloid. No displacement. Sustained in a fall. Resembles a Chauffeur's.
- No. 39. J. Y., age 31. Fracture of radial styloid. No displacement. There is distortion present owing to the rotation of the bones when the film was taken. Fell from a ladder. Resembles a Chauffeur's.
- No. 40. F. M., age 34. Fracture in the distal end of the radius. No displacement. Fell off a truck. Resembles a Chauffeur's.
- No. 41. I. Y., age 62. Comminuted fracture in distal end of radius with fracture of ulnar styloid. Fell down steps.
- No. 42. E. F., age 77. Fracture of both bones in the distal end.
- No. 43. L. N., age 53. Fracture of both bones in the distal third. In auto accident.
- No. 44. J. G., age 46. Comminuted fracture of the distal end of radius. Unusual violence. Fell from a ladder.
- No. 45. M. M., age 35. Comminuted fracture of the distal end of the radius.
- No. 46. E. B., age 40. Impacted fracture distal end of radius. Circle passes through fracture line, although ulna is slightly short, with an unusually large styloid.
- No. 47. J. D., age 35. Fracture in distal end of radius with fracture of ulnar styloid. Unusual violence. Fell down stairs.
- No. 48. A. M., age 41. Fracture in distal end of radius. Circle misses by 0.5 cm., but note the rotation of the radius in taking the film. Such a fracture will fall on the line in a direct a-p view.
- No. 49. S. I., age 49. Fracture in the distal end of radius with fracture of the ulnar styloid.
- No. 50. J. M., age 30. Comminuted fracture in the distal end of radius with ulnar styloid fracture.
- No. 51. J. N., age 63. Fracture in the distal end of radius. Note the ulnar styloid shadow in the middle of the distal end of the ulna. The compass point is placed at the usual site on the ulna, ignoring the rotation of the ulna when the film was taken.
- No. 52. E. S., age 31. Fracture in the distal end of radius with ulnar styloid fracture.
- No. 53. M. M., age 43. Fracture in distal end of both bones.
- No. 54. C. D., age 65. Fracture in distal end of radius with ulnar styloid fracture.
- No. 55. M. F., age 42. Fracture in distal end of both bones.
- No. 56. F. D., age 26. Fracture in distal third with callus formation. There is some rotation in taking the film, so that the circle misses the convex flare of the radius. The fracture is a true atypical fracture, in that it shows a fracture of the ulnar styloid associated with a fracture in the radius at an unusual level, well proximal to the circle. Fell while intoxicated.
- No. 57. G. S., age 38. Comminuted fracture in distal end of radius. Fell down steps.
- No. 58. H. L., age 49. Fracture in distal end of radius with ulnar styloid fracture. There is distortion of the film because of rotation, and an unusually long ulna. Circle misses by 0.5 cm.
- No. 59. A. S., age 48. Fracture of the radial styloid and a spiral fracture in the distal end of the ulna.
- No. 60. F. S., age 34. Fracture in distal end of right radius. Circle misses slightly. Note the unusually long and peculiarly shaped distal end of the ulna. Slight rotation in taking the film.

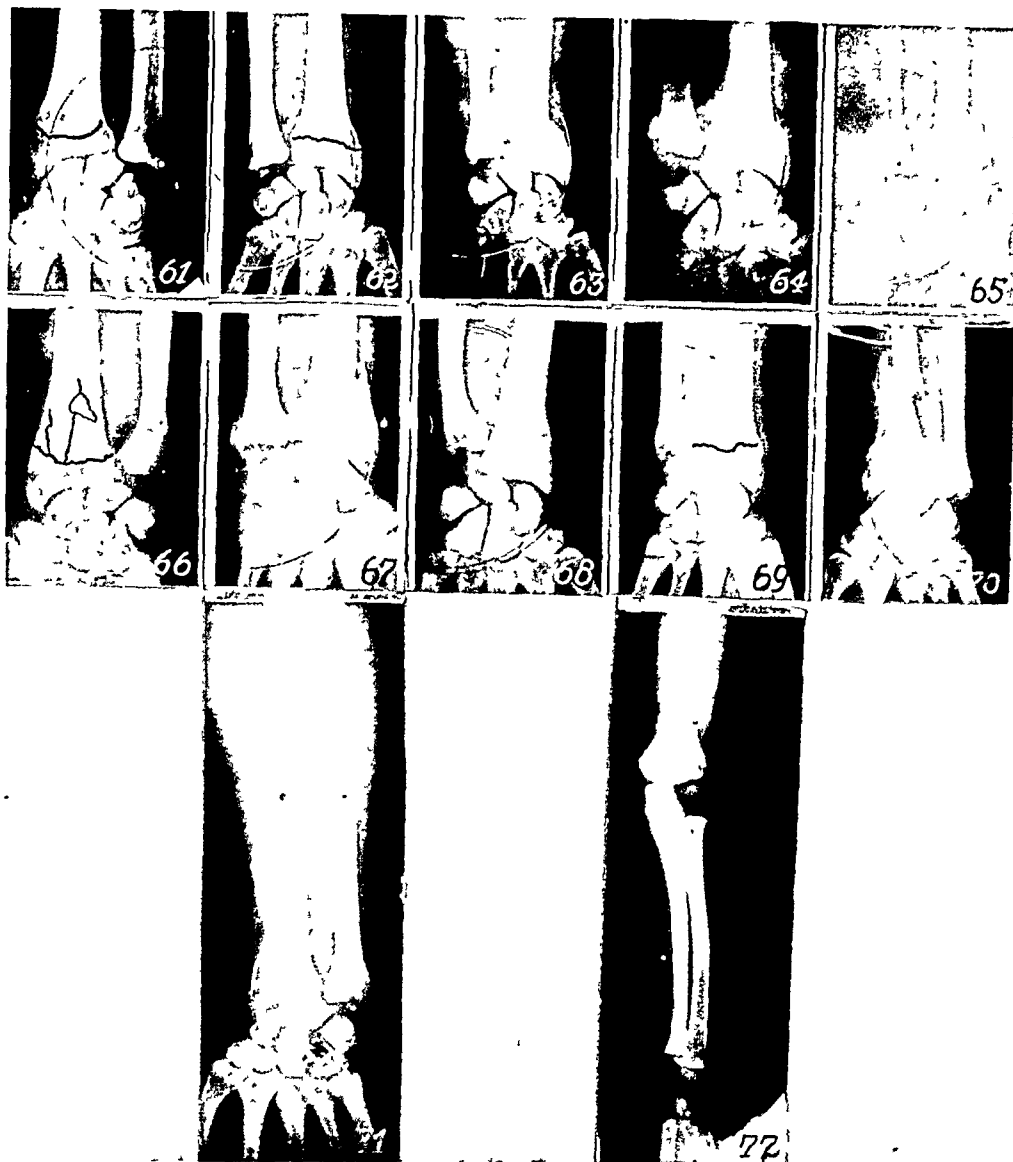


PLATE III.

No. 61. A. B., age 46. Fracture in the distal end of radius. Circle misses. Note the long ulna. In this case, the os capitate was very much shortened, because of old fracture or disease, and the case was the only one like it seen in the last five years. The condition in the os capitate was not acute, or of recent origin and was undiagnosed.

No. 62. A. H., age 52. Fracture in the distal end of radius with ulnar styloid fracture. Circle misses, owing to rotation in taking the film.

No. 63. C. B., age 39. Comminuted fracture in the distal end of radius. Fell down steps. Note that the use of the circle determines the amount and direction of displacement at a glance. It may pass through the end of the fracture line on either fragment, depending upon which fragment is displaced out of line with the hand.

No. 64. A. R., age 49. Fracture in the distal end of the radius and ulnar styloid fracture. The circle here passes through the end of the fracture line on the distal fragment. The medial displacement of the ulnar styloid fragment in this case was the only one seen and is included for that reason. Unusual violence. Fell from a ladder.

No. 65. A. K., age 35. Comminuted fracture in the distal end of radius. Unusual violence. Fell down steps.

No. 66. J. R., age 60. Comminuted fracture in the distal end of radius with ulnar styloid fracture. Unusual violence. Fell down steps.

For remainder of legend see opposite page.

run through bones, are represented by fasciculi of bone elements which fuse whenever the pressure lines are close together, but leave spaces between them whenever the pressure lines pass through relatively large transverse areas—as in joint surfaces. In each position of the joint surfaces a series of pressure lines passes from one bone to the other. So in the first place the number of these positions, i.e., the mutual mobility of the joint surfaces determines the texture of cancellous tissue."

It seems reasonable to believe that a fracture will always occur in the area of greatest stress. The fracture line occurs in a more proximal position in children, through cortical bone. Presumably this area of the shaft in a child's radius is as strong as other portions of the same bone.

7. *Why do patients in the years from 8 to 16 sustain epiphyseal separations?*

It is true that radial epiphyseal separations in the majority of cases tend to occur between these years, and this condition has been taught as an entity, unrelated to other lesions. If one observes the fracture line in different age groups, he will find the younger the patient, the greater will be the distance of the fracture line from the wrist joint (1 to 1½ inches). (Plate I, Figs. 1-24.) As age increases, the fracture line approaches the wrist joint, until in the adult it is usually ½ to ¾ inch from the joint. As the center of rotation in the distal ulnar end moves distally, and the fracture line tends to fall closer to the wrist joint, a period of growth arrives in the years from 8 to 16, in which the zone of greatest stress coincides with the distal radial epiphysis. It appears that the area of greatest stress in

the radius moves distally with the distal growth of the ulnar styloid area. That the epiphyseal line is not an especially weak area, prone to separation with fracture of its margins, is amply demonstrated by the fact that for the years prior to the age of 8 or 9, fracture may occur proximally while the epiphysis escapes injury. (Plate I, Figs. 3, 5, 6, 14, etc.)

8. *In relation to the mechanics of fracture production, does the theory of ligamentous action in tearing off the distal end of the radius find support in this study?*

No. If the theory of ligamentous action is accepted in the mechanism of fracture production, it is necessary with the same theory to explain: (1) the impacted fracture; (2) the comminuted fracture with a v or T line extending into the articular surface; and (3) the suprastyloid fracture in children, in which the fracture is above the attachment of the ligaments. Also, if the ligamentous theory is accepted, it must be assumed that the ligaments on the flexor surface of the wrist are always stretched to their limits in a fall on the hand. That is to say, that an individual always falls on a hand held in extreme dorsiflexion. This was thought improbable.

It seems more logical to believe that ligaments about a joint come into play only when the muscles which control the movements in the joint have been ruptured or stretched to their utmost. In the case of muscles stretched to their maximum length, they may then act as ligaments across the joint line.

T and v fractures into the joint surface are thought by some to represent the result of greater force. This is reasonable, but raises the question of why we should

No. 67. M. G., age 38. Comminuted fracture in the distal end of radius with ulnar styloid fracture. Unusual violence. Fell from a stepladder.

No. 68. J. K., age 17. Fracture in distal third of radius with longitudinal fracture of the ulna. Note how the bending of the ulna toward the radius causes the circle to miss the fracture line. This arm was caught in a high speed lathe.

No. 69. A. O., age 37. Fracture in the distal end of radius. Circle misses slightly. Note the short ulna.

No. 70. E. R., age 52. Fracture in the distal third of radius. Circle misses. Atypical.

No. 71. J. J., age 22. Fracture in the middle third of radius with ulnar styloid fracture. Circle misses. Atypical.

No. 72. E. A., age 4. Full length view of the forearm bones.

observe this type of comminution, rather than another fracture more proximal in the same bone or in the humerus. The suggestion is offered, that with extreme violence, the comminution is the result of complete utilization of the protective articular mechanisms of the body, such as joint rotation. The r or v comminution is a spiral or oblique fracture of the fragment, and would seem to indicate a torsion force acting on the fragment.

9. *Are growth changes in the distal end of the radius and ulna of any importance in this study?*

Growth changes here are considered very important and are briefly described, as well as illustrated in the accompanying figures. (Plate I, Figs. 1-24.) These changes are also clearly shown in the monograph by Eliason et al.<sup>3</sup> Before the age of 6 or 7 months, the carpus as recorded by the x-ray is devoid of any ossification center. The hand at this age and for the first few years of life is a flexible flipper hand, in which the cartilage component is much higher than in that of the adult. It may be assumed that this cartilaginous hand and carpus do not function as a firm unit for leverage in quite the same manner as do the more rigid bony hand and carpus of the adult. The ratio of the length of the hand and carpus to the length of the forearm is changed by growth to adult life. One newborn wrist (Figs. 9 and 10) was measured, and the distance from the tip of the third finger to the radiocarpal joint was equal to the length of the forearm when measured from the radiocarpal joint to the anterior flexion crease of the elbow. A few adult measurements made from the proximal volar flexion crease at the wrist to the tip of the third finger in one direction, and to the flexion crease of the elbow proximally, demonstrated an approximate ratio of seven for the combined length of the hand and carpus to nine for the length of the forearm. The changing ratio of length, as well as the flipper-type hand of the child, are factors to be considered in a fracture study of the forearm bones at this age. This

newborn wrist was dissected primarily to learn whether or not the anatomic relationships about the medial ligaments of the wrist, and the attachment of the triangular fibrocartilage, were the same as in the adult. They were found the same.

Approximately at 6 months the ossification center for the os capitata begins to appear. At this age, there is no epiphyseal plate for the radius or ulna. Both bones are straight, with a slight concave flare at the distal end, on either side of each bone. It is especially important to notice that the level of the distal end of the ulna is from  $\frac{1}{4}$  to  $\frac{1}{2}$  inch proximal to that of the radius. At 18 or 20 months, the radial epiphyseal plate becomes visible. The ulna is still short. Centers of ossification for the os capitata and hamate bones are visible. At three years, the ossification centers for the capitata, hamate and triangular bones are present, while the ulna remains short. At 7 or 8 years, all bones are present in the carpus and the epiphyseal plates of the radius and ulna are present.

At this age, from 7 to 9 years, when all the bones of the carpus are shown, certain changes occur in the radius. It loses its slight concavity along the distal borders, and begins to show a bulging outward above the epiphyseal line. At the age of 14 or 15 years, the lateral side of the lower end of the radius is convex outward; while the lower articular surface of the radius has been drawn distally, owing to the more rapid growth of the radial styloid, so that the radial articular surface now faces toward the ulnar side of the carpus. It is an interesting fact that this developing lateral convexity of the distal end of the radius, as well as the directional change in the facing of the distal radial articular surface toward the ulnar side, are both concurrent with the development of the ulnar styloid. The distal end of the ulna is still found to be somewhat proximal to its final adult position in relation to the radius.

At the age of 17 to 19 years, the epiphysis in each bone has united, leaving both the radius and ulna with an outward convexity

at the distal end. The convexity of the radius above its styloid is the much more striking of the two. The ulna has now assumed its adult position in relation to the radius, in which the distal end of the ulna is at the level of the ulnar side of the distal articular surface of the radius.

There is danger of confusing cause and effect in seeking the answer to the question of whether or not these growth changes in the bone contour represent the effect of a continuous rotatory force, centered in the distal end of the ulna, and acting in the coronal as well as in the sagittal plane. In such a debatable field, it is sufficient to recognize these changes, and to stress the most important point of all; namely, that the growth changes in the two bones are concurrent. In the light of the above observations, it may be fairly stated that the shape of the radial styloid and the ulnar-faced curvature of the distal radial articular surface are admirably fashioned and buttressed to receive and sustain pressure forces from a carpus moving along the circumference of a circle, whose center is found in the styloid of the ulna.

10. *Why is the lateral view of the x-ray film in suprastyloid fracture ignored?*

It is unnecessary to discuss the lateral view of these fractures. The dorsal rotation of the fragment is obvious and well known, and lateral views are more difficult to read. If the lateral end of the fracture line inevitably falls in the radius at a point equidistant with the second carpometacarpal joint, from the base of the ulnar styloid, it will be equidistant by measurement in any plane.

11. *Does the circle, upon which the classification is based, intercept the junction of the fracture line and the lateral border of the radius exactly in every case?*

No. The circle may miss the fracture line a distance of 0.5 cm. or so in the occasional case. It is not strictly applicable to transverse fractures at the base of the radial styloid (chauffeur's), although this fracture falls within its circumference. This fact accentuates the value of the circle. The

mechanics of a fracture by backfire force are probably different from those in a fall on the hand. Fracture of the radial styloid base is a typical fracture for backfire force, but it is atypical when received in a fall on the hand. The circle test is more apt to fall astray in epiphyseal separation than in any other condition, possibly because the entire distal end of the ulna may bend without fracturing in children, causing the actual center of rotation in the ulna to fall at some point proximal to the distal end. The application of the test to reversed Colles' found it true in some cases and not in others. A clue as to why it may or may not work in reversed Colles' may be seen in the fact that some are true reversed fractures, and others are anterior fracture dislocations of the wrist.

An incidental result of continued application of the circle test is a tendency to examine the films much more closely than heretofore. Small amounts of distortion by rotation in taking the film are noted. An occasional short ulna, or an adult radius in which the lateral convexity is poorly developed, are quickly noticed.

12. *In a subject of this importance, dealing with an area in which most fractures occur, would it not be wise to make a complete study of consecutive fractures in the forearm bones in all the different fracture sites?*

This was considered necessary in establishing the classification. The circle test, to be of any value in classifying these lesions into one mechanical group, must include all typical fractures and must exclude all atypical fractures. Ashhurst<sup>1</sup> wrote: "the more one studies the subject, the fewer exceptions he will find to the general laws of mechanics; and the more his experience increases, the easier it will become to recognize the variants from the typical lesions."

At the outset, the films of all fractures of the radius and ulna in the x-ray files of the Episcopal Hospital in 1931 and 1932 were studied. They are listed below.

1. Suprastyloid fracture of the radius, combined with ulnar styloid fracture..... 152

2. Suprastyloid fracture of the radius, minus fracture of the ulnar styloid 122  
(74 were 15 years of age or younger; 48 were over 15 years of age.)
3. Suprastyloid fracture of both bones near the wrist 65  
(Oldest was 15 years; youngest 15 months; majority were 3-10 years of age.)  
(Two of these, age 9 and 13, were sustained in cranking a car.)
4. Epiphyseal separations of the radius 30  
(1 age 8; 2 age 9; 3 age 10; 1 age 11; 4 age 12; 5 age 13; 5 age 14; 3 age 15; 3 age 16; 1 age 17; 1 age 18; 1 age 19.)
5. Fracture of the radial styloid 25  
(17 of these were sustained in cranking a car.)
6. Fracture of the ulnar styloid alone 7  
(Usually by direct violence.)
7. Reversed Colles' fracture 6
8. Fracture of both bones proximal to the supra-styloid area 146
9. Fracture of the radius alone, other than head, neck or distal third 16  
(In upper third 10; 4 age 9, 1 each at 10, 11, 12, 13, 16 and 27.)  
(In middle third 6; ages 5 (2), 6, 10, 11 and 17.)
10. Fracture of the ulna alone, aside from the styloid 18  
(11 of these were spiral or oblique in upper, middle and distal thirds.)  
(6 were step fractures and one was green-stick.)
11. Fracture of head and neck of radius 28  
(5 of these were associated with posterior dislocation of the elbow.)
12. Fracture of the coronoid process 5
13. Fracture of the olecranon process 13

Fractures in the last two groups were often associated with other fractures about the elbow, often atypical. In order to gain a better idea of the ages of the epiphyseal separations, a second group of fifty-two was studied. The ages were: one age 2; one age 4; one age 7; two age 8; three age 9; three age 10; two age 11; thirteen age 12; nine age 13; nine age 14; four age 15; three age 16; one age 18.

The first four divisions are placed in one group by the circle test, and represent more than 50 per cent of all forearm fractures.

It was noted that oblique, spiral and so-called step fractures occurred in areas which are not protected by an adjacent joint permitting rotation. Fractures in bones near joints which permit free motion in more than one plane are commonly

transverse fractures. Examples of this are seen in the transverse fracture of the surgical and anatomic necks of the humerus and the femur; in the supracondylar fracture near the elbow, where with the hand fixed, the extremity may rotate on the head of the radius; and in the suprastyloid fracture of the radius. Aside from the styloid and olecranon, spiral fractures are typical for the ulna.

The conditions existing in the radius are unusual and a spiral or oblique fracture is atypical for this bone. The radius is so arranged that rotation for the entire bone is easily permitted, in that it is a parallel bone to the ulna, where the ulna represents the fixed portion of this arrangement. The wrist joint is a diarthrodial joint, allowing motion in two planes so freely as to resemble the free rotatory motion of an enarthrodial joint. This movement of the wrist joint is possible, however, only in 180 degrees extension, and becomes progressively less as one approaches complete dorsal flexion, in which position the carpus is fixed in the joint, and the movements of radial and ulnar deviation completely disappear. Dorsal flexion is the position of the hand in falling, and the movements of the wrist in this position are limited. One might question the rotation entering into this arrangement, which could protect the suprastyloid area from a twisting force. The answer is found in the fact that the ulna is free to rotate on its own axis in the distal radio-ulnar joint, and with the humerus, it rotates around the head of the radius when the elbow is extended and the hand is fixed.

Spiral and oblique fractures, which may be assumed to represent the result of torsion forces, are commonly found in the middle of the shafts of the long bones, as in the humerus, the ulna where the spiral and so-called "step" fractures are the rule, and in the middle and distal thirds of the tibia where, with the knee in the extended weight-bearing position, there is an absence of any protective rotatory joint motion. They are also seen in the distal fragment in

the T or V comminuted fracture of the suprastyloid area.

The films pictured in the three plates were selected to show the less accurate applications of the circle test and the reasons therefore. Some cases showing its exact application are interspersed. In order to show the growth changes, the figures in Plate I, Figures 1 to 24 are arranged in the order of increasing age. These are routine films taken by Dr. R. S. Bromer, former roentgenologist to the Episcopal Hospital.

#### SUMMARY

The leverage effects of the hand and carpus in the production of suprastyloid fracture in the radius by a fall on the hand have been studied. Applied anatomy from original dissections; an analysis of all types of fractures of forearm bones for a two year period; and a series of x-ray films with illustrative circles drawn, have been presented in an effort to correlate the applied anatomy of the region with the known incidence and location of fracture as recorded by x-ray. A classification based upon a circle test used in anteroposterior films is submitted.

#### CONCLUSIONS

The location of the fracture line in the distal end of the radius, sustained in a fall on the hand, bears an unchanging relationship to the bones of the carpus, irrespective of the patient's age. This relationship is

demonstrable in a high enough percentage of cases to remove it definitely from the realm of coincidence. It is suggested that epiphyseal separation in the distal end of the radius, is the result of increased stress occurring at that site during a certain age period, and not the result of an assumed weakness of the epiphyseal line.

Anatomic material was provided by the unfailing generosity of Dr. E. R. Clark, Professor of Anatomy in the Medical Department of the University of Pennsylvania. I am indebted to Mr. B. B. Varian in the same department for the pictures of the dissections shown in all the figures, and for the film photographs shown in the plates. Dr. Lowry Allen, roentgenologist to the Episcopal Hospital, kindly made the films pictured in Figures 12, 13, 14 and 15. Lettering, numerals, and the diagrammatic sketch shown in Figure 6, are by Miss Edna Hill of the University of Pennsylvania Hospital.

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# ACROMIOCLAVICULAR AND STERNOCLAVICULAR JOINT INJURIES\*

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THE clavicle is unique in that while acting as the principal support that keeps the shoulder girdle from collapsing upon the thoracic cage, the clavicular articulations at both its inner and outer ends mechanically are the most unstable joints in the body, being entirely dependent upon the ligamentous attachments for their integrity. That the acromioclavicular and sternoclavicular joints are not more often subluxated, is probably due to the great range of the glenohumeral and scapulothoracic movements. The one force to which the clavicular joints will yield most readily is a lateral thrust. Should the thrust be sudden, violent and directly from the side, dislocation of the sternal end of the clavicle is most likely to occur. When the lateral thrust has a caudad component, or particularly if it acts from the posterior aspect of the shoulder, the acromioclavicular joint bears the strain, and may yield with partial or complete dislocation. While fracture of the clavicle is common in childhood or adolescence, true acromioclavicular or sternoclavicular dislocation rarely occurs at these ages, and is almost always encountered in adults, in whom clavicular dislocations are far more frequent in relation to the number of clavicular fractures than in children.

According to the amount of force and the time through which it acts, injuries of the acromioclavicular joints may be divided into sprains, incomplete dislocations (subluxations) and complete dislocations of the joint. In the sprain, pain on motion of the arm, particularly on elevation or load lifting, tenderness at the joint, and local swelling are encountered. At times, abnormal motion, not found on the normal uninjured

joint, is encountered. Naturally, the transition stage from sprain to separation is not great, and it is often difficult in the first few days to judge whether the injury is a severe sprain or partial subluxation, until the response to therapy is observed. There are no demonstrable changes found in the radiographs of such cases.

When greater force has acted, definite abnormal false motion is present, the tenderness and swelling of the joint is marked, and usually marked difficulty is experienced in the use of the injured limb. In x-rays of the shoulder, (anterior-posterior) taken with the patient sitting or standing, the outer end of the clavicle is found displaced upward from 2 to 4 mm. above its usual level in relation to the acromion. In such incomplete dislocations of the acromioclavicular joint, the superior and inferior acromioclavicular ligaments are torn, and not infrequently, there is evidence that the coracoclavicular ligaments may suffer damage of varying extent as well.

In complete acromioclavicular dislocation, attempted elevation of the injured arm increases the obvious deformity, and the clavicle may ride above and project beyond the medial articular border of the acromion. It is not fully recognized that posterior displacement of the clavicle in relation to the acromion is present in every case as well. By comparing the anterior-posterior radiographic projection (Fig. 1) with the lateral view of the same case, this wide separation is vividly portrayed. Such lateral roentgenograms may possibly be of value in determining the true degree of some of the severe "incomplete" acromioclavicular separations, for the roentgen-

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ologist's appreciation of the true clinical condition often is at variance with the physical signs found in the injured shoulder.

function, *controlled motion*, was neglected. The acromioclavicular joint, a diarthrodial articulation, is constructed for motion.



FIG. 1A. Anteroposterior roentgenogram taken with patient standing, showing a clinically complete acromioclavicular dislocation with tear of trapezoid and conoid coracoclavicular ligaments.

Sir Robert Jones<sup>1</sup> remarked of acromioclavicular dislocations; "Replacement is easy. Retention of the bones in position long enough to insure strong repair is almost entirely neglected by the majority of the profession." His form of treatment consisted in the use of the brachioacromioclavicular sling, and apparently in his hands it was quite adequate. There are many modifications of this device, and all employ the general principle described by Jones. Inability to maintain the reduction, pressure phenomena about the tip of the olecranon, and probably unintelligent use of the method gradually led to the conception that complete acromioclavicular dislocations never healed without excess mobility, and that frequently a painful, unstable arm and shoulder were the result of the injury.

Operative methods varied from the use of a single wire suture, bone pegs, bone grafts, to the insertion of a long thin wood screw through the acromion, across the joint, into the clavicle. While at first glance, these efforts seemed to solve the problem, in practice, wires or pegs broke, screws went astray unless guided by a sharpshooter, and the essential point of restoration of joint



FIG. 1B. Lateral roentgenogram of same shoulder, showing marked dislocation of clavicle backwards. The extent of separation cannot be appreciated in stereo-roentgenograms.

One ordinarily thinks of shoulder motion taking place at the glenohumeral joint, and while recognition of concomitant movement is universal, the part played by acromioclavicular and sternoclavicular joints is often lost sight of. Mollier,<sup>2</sup> whose studies are not generally available, gives the range of motion in the joints as follows:

	Degrees
Acromioclavicular joint axes:	
Vertical	15
Sagittal	19
Frontal	29
Sternoclavicular joint axis	
Vertical	37
Sagittal	20
Horizontal	22

He has demonstrated very clearly that for every change in position of the scapula, there is a corresponding change in the position of the clavicle reflected by movement at these two joints, and if either or both should be fixed and immobile, the total range of shoulder motion would be markedly impaired.

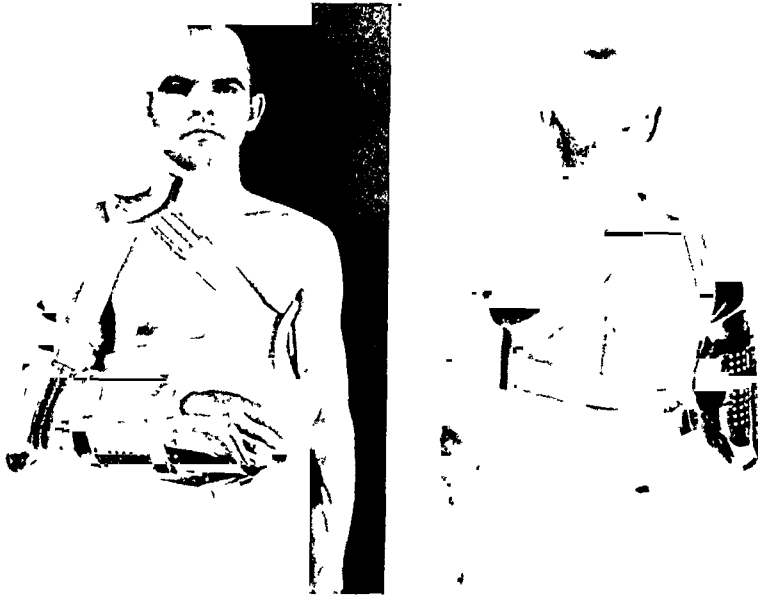


FIG. 2. A, a metal right angled external elbow splint is well padded with saddler's felt. The patient's arm is heavily wrapped with cotton sheet wadding. The splint is applied to the arm with adhesive and gauze bandage. Then the acromioclavicular region is injected with 1 per cent novocaine, the dislocation of the joint reduced, and the elastic traction bands applied as shown. The traction bands are made of 2 inch cotton webbing, sewed to a central 2 foot strip of heavy 2 inch woven elastic webbing. B, back view. Note that the posterior vertical traction strap (gray striped) is carried beneath the encircling body strap. This holds the arm to the side securely. After two or three weeks in complete dislocations, the elastic vertical strap may be placed outside to allow beginning shoulder motion.



FIG. 2. C and D, side views. Both strap crossings are anchored by slotted felt pads, which also ensure comfort.

Bunnell<sup>3</sup> realized the inadequacy of operative treatment by fixation, and stressed the fact that the tearing of the coracoclavicular ligaments was the essential feature in complete acromioclavicular dislocations. He devised a fascial suture plastic reconstruction of these structures as well as suture with fascia and silk of the acromioclavicular joint itself. Henry<sup>4</sup> of Minnesota had previously used such a method, and later described the operation. Ralph F. Bowers<sup>5</sup> reported six cases in which reconstruction of the ligamentous apparatus was carried out by means of heavy braided silk. The results of the operation in the hands of these surgeons were good. It cannot be said, however, that as a whole, the operative reconstruction of the ligaments has been followed by early return to work without residual disability.

Since 1932, in the Fracture Clinic of the Stanford Surgical Service, we have used a modification of the brachiooclavicular sling which has proved satisfactory and adequate in the complete as well as the incomplete subluxations of the acromioclavicular joint. The effectiveness of the splint depends upon (1) immobilization of the elbow of the injured arm at a right angle, thus furnishing—a stable fulcrum from which effective upward traction of the arm and shoulder may be obtained; and (2) the use of elastic traction at the same time pressing downward upon the clavicle while the splinted arm, with its acromion, is pulled upward. The principles embodied in the splint are far from new, but the simplicity of the apparatus, and its effectiveness recommend its use. (Fig. 2.)

Certain suggestions may be added that may seem unnecessary, but in the light of teaching experience and practice deserve restatement. No splint on application reduces a fracture or dislocation by itself. The act of reduction must first be accomplished by the physician and then maintained by proper application of the apparatus. Novocaine (1 per cent, 10 to 15 c.c.) is usually sufficient for anesthesia and muscular relaxation. In these complete

dislocations with the acromion riding forward under the clavicle, the operator's fist in the patient's axilla serves as a fulcrum, and the patient's arm can be brought to the side of the body, levering the shoulder girdle and the acromion laterally from beneath the projecting clavicle. The flexed and splinted elbow is then pressed upward and backward, while the operator's opposite hand shoves the clavicle down and forward into its accustomed articulation with the acromion.

The dislocation reduced, the elastic and cotton webbing strap from the elbow is crossed over the injured shoulder, held in place above medially on the clavicle by slotted felt pads; crossed again in the opposite axilla (a similar slotted felt pad prevents chafing and "riding up" at this crossing) to encircle the body for final buckling or fastening. The slotted felt pads are important in that they insure the strap crossings' remaining in the desired position and prevent "creeping" as well as chafing of the skin.

For the first two weeks arm motion is prevented by passing the encircling body strap over the posterior vertical traction band of the arm. After a fortnight, the encircling body strap may be passed directly around the body, leaving both vertical arm traction straps free. The patient may then abduct, forward flex, and rotate the shoulder within a fairly wide range (70 degrees) without pain or recurrence of the dislocation, and so prevent shoulder stiffening and contracture. The splint should be used for four to five weeks in all complete separations, following which the usual muslin sling may be used until elbow and shoulder motions, encouraged by exercise, are quite free and comfortable.

Since 1932 we have treated thirty acromioclavicular joint injuries in the fracture clinic of Stanford Surgical Service and in private practice. The severity of the injuries and the end results are summarized in the accompanying charts. Naturally, sprains of the joint recover promptly, but as mentioned before, the gradation from

severe sprain to subluxation is not sharp, and the more disabling sprains recovered quickly with the use of the brachio-clavicu-

The virtue of the splinting method is best shown in the ten complete acromioclavicular dislocations (Chart III). All of these

### ACROMIO-CLAVICULAR SPRAIN

AGE	SEX	TREATMENT	DAYS OF DISABILITY
17 years	Male	Strapping	None (school boy)
21 years	Male	Sling	10 days
16 years	Male	Sling	6 days
20 years	Male	Sling	Not followed
33 years	Male	Sling	10 days
47 years	Male	Strapping and sling	8 days
21 years	Male	Strapping and sling	6 days
40 years	Male	Strapping and sling	21 days
33 years	Male	Brachio-clavicular splint.	6 days
22 years	Male	-----	Not followed

Average age—28 years.

Average disability—8 3 days

CHART I.

lar traction splint. Relief of pain was noteworthy in every case in which the splint was used. Most of the patients had strapping, muslin slings or Velpeau's bandages when first seen. The relief is immediate and coincident with real support of the weight of the dependent arm. (Chart I.)

patients have returned to active work, have been followed, and have remained free of pain, and of instability of the shoulder joint. (Fig. 3.)

An injury similar in nature and occasionally accompanied by subluxation of the acromioclavicular joint is fracture of the

### ACROMIO-CLAVICULAR SEPARATIONS, INCOMPLETE.

AGE	SEX	TREATMENT	DAYS OF DISABILITY	PERMANENT DISABILITY
12 years	Male	16 days	16 days	None
45 years	Female	Sling 3 days — splint strap 3 days 5 weeks	55 days	None—returned to work
27 years	Male	44 days no — splint treatment 3 weeks	65 days	None—returned to work
21 years	Male	Strapping — splint 9 days 21 days	34 days	None—returned to work
65 years	Male	Sling — splint 1 week 2 weeks	29 days	None—returned to work
26 years	Male	splint 20 days	56 days	None (also fracture of scapula)
33 years	Male	splint 32 days	48 days	None

Average Age—32 7 years

Average period of disability—43 2 days

Permanent disability—none

CHART II.

In the incomplete separations or subluxations, the results were quite as satisfactory with an average of 43.2 days away from work; no permanent disability remained. (Chart II.)

outer end of the clavicle distal to the insertion of the coracoclavicular ligaments. Without tear of the coracoid and trapezoid ligaments the displacement of fragment is minimal and is easily treated, occasionally

with a simple sling. When the ligaments are torn, however, the displacement may be extreme. In such patients the brachio-clavicular splint was effective in maintaining alignment and contact of the fragments. (Chart iv.) In one patient an uncoöperative alcoholic transient, no adequate reduction was obtained and no follow-up could be secured. This patient had a severe abrasion and contusion of the elbow. The application of the brachio-clavicular elastic traction splint was followed by ulnar palsy. The one prolonged disability was in a patient who developed acute renal colic with calculus. He was referred to the genitourinary clinic and did not carry out the prescribed exercises. Prolonged stiffness of the shoulder was the result.

Sternoclavicular dislocations occur far less frequently than the separation at the outer end of the clavicle. With complete dislocations of this joint the extra-articular ligamentous structures suffer as well as the ligamentous portions of the joint capsule. Here the costoclavicular ligament ruptures and allows the clavicle to ride forward and across the jugular notch. In treatment of these infrequent injuries, operation has not gained the popularity that reconstructive surgery of the acromioclavicular joint enjoys. Nevertheless conservative treatment is often ineffective and results in laxity of the joint ligaments and recurring subluxation on heavy effort, which is rarely disabling to an extreme degree.

Those hopeful methods that attempt to maintain the medial bulbous clavicular end in its shallow articular facet by pressure pads over the joint are useless. They conceal the recurring dislocation beneath layer on layer of adhesive. The shoulder can be used as a fulcrum to good purpose, however, and by applying a well fitted clavicular cross, and by so pulling the shoulders and the clavicle up, out and back, one can maintain the sternoclavicular joint in its normal relations until the costoclavicular and articular ligaments are healed. The

joint can be inspected at all times and the splint readjusted. At least four weeks of constant wearing of the cross splint are



FIG. 3. A, complete acromioclavicular dislocation with the clavicle overriding the acromion, while the entire shoulder girdle has dropped down and forward. One's fist in the patient's axilla serves as a fulcrum, the patient's arm serves as a lever, and adducting the elbow to the body forces the shoulder girdle outward to allow reduction of the dislocation. B, same joint twenty-seven months later. Clinically there is no deformity, no false motion, no pain and no limitation of motion as compared with the normal shoulder, in spite of mild arthritic changes in the joint.

necessary to allow adult normal tensile strength to be developed in the torn ligamentous structures. Three patients treated in this manner recovered with no false motion or tendency to subluxation of the joint, and their average disability was fifty-four days. One of these patients suffered an oblique fracture of the inner end of the clavicle, splitting the joint surface, the subsequent displacement taking the form of the usual sternoclavicular dislocation. The reduction and maintenance of

position was carried out in the same manner as for a dislocation. The patient recovered with normal motion of the months of disability. At the end of that time the injured sternoclavicular joint was still subluxated on lifting efforts and was a

## ACROMIO-CLAVICULAR DISLOCATIONS, COMPLETE

AGE YEARS	SEX	TREATMENT		DAYS OF DISABILITY	PERMANENT DISABILITY
		SLING, STRAPPING OR BANDAGE	BRACHIO-CLAVICULAR SPLINT		
30	Male	4 days	34 days	51 days	None—returned to work
29	Male	5 days none	30 days	49 days	None—returned to work
48	Female	————	35 days	56 days	None—returned to work
33	Male	Bed 15 days sling 15 days	Splint—55 days	120 days	None—returned to work
24	Male	————	Splint—35 days	46 days	None—returned to work
69	Male	————	Splint—42 days	84 days	None—returned to work
48	Male	————	Splint—22 days	75 days	None—returned to work
32	Male	Strapping 3 days	Splint—30 days	42 days	None—returned to work
57 *	Male	————	Splint—36 days	130 days	10 degrees loss forward flexion 20 degrees loss of abduction
17 (*)	Male	Strapping 26 days	————	47 days	Abnormal mobility still present—pain in heavy lifting

Average Age—38.7 years.

Average Disability—70 days.

Permanent Disability \* Head injury, marked scapulo-humeral, acromio-clavicular and spinal arthritis

(\*) 1932—Inadequate treatment by strapping only

CHART III.

shoulder, but with excess callus at the site of injury. One may contrast treatment with the clavicular cross with other forms as shown by two patients in Chart iv. One source of minor distress. The other patient was treated with adhesive pads across the joint surface and a sling for the forearm. A cross was applied, but the patient refused

## FRACTURE OF CLAVICLE INVOLVING ACROMIO-CLAVICULAR JOINT.

AGE YEARS	SEX	TREATMENT		DAYS OF DISABILITY	PERMANENT DISABILITY
		SLING, BANDAGE STRAPPING	BRACHIO-CLAVICULAR SPLINT		
29	Male	Sling 14 days	Splint 18 days	Alcoholic trans- sient. Uncooperative Did not return.	Ulnar Palsy
34	Male	Sling 21 days	Splint 21 days	56 days	None—good function
47	Male	Velpeau bandage 6 days	Splint 5 weeks	180 days	Head injury. Brachial Plexus neuritis, recovered) None
67	Female	Velpeau bandage 4 days Inadequate splint for 2 weeks	Adequate splint 4 weeks	Still under treatment	
23	Male	Strapping and sling 4 weeks	No displacement of frag- ments Fracture between joint and ligaments	30 days	None—returned to work

## STERNO-CLAVICULAR DISLOCATIONS

26	Male	Clavicular cross 1 month		49 days	None
33	Male	Aeroplane splint 6 weeks (referred from country) Sling 1 month		6 months	Unstable joint Pain on lifting
64	Female	(fracture) Clavicular cross 30 days		57 days	None
65	Male	(fracture) Adhesive strapping 23 days	Sling 14 days	37 days	— sent to Prison Deformity and subluxation still present. None
50	Male	(fracture) Clavicular cross 4 weeks		8 weeks	None

CHART IV.

was treated with an aeroplane abduction splint for six weeks, given a sling for one month, and had as a consequence six to wear it, and thirty-nine days after the injury, the deformity still recurred on raising the arm.

## SUMMARY AND CONCLUSIONS

1. Acromioclavicular dislocations, complete or incomplete, can be adequately treated by simple means, and operation is unnecessary in most cases.

2. The retention apparatus must be worn for a time sufficient to allow the torn trapezoid and conoid, as well as the acromioclavicular ligaments, to heal in a shortened position and with normal adult tensile strength. Four weeks usually suffice.

3. A satisfactory simple method of maintaining reduction of the acromioclavicular joint dislocation is described.

4. The same means may be used in certain fractures of the outer end of the clavicle, in which tear of ligaments and deformity similar to that in tears of the acromioclavicular ligaments occurs.

5. Sternoclavicular dislocations while rare, can be maintained in reduction by the

clavicular cross and normal joint movement and stability regained.\*

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\* Since this manuscript was submitted for publication, four complete acromioclavicular dislocations have been treated with the brachial clavicular traction splint. Three patients returned to work with no disability or deformity and with normal motion. The fourth, a patient who had a fractured carpal scaphoid of the same arm, finally came to operation.





# ACUTE FRACTURES OF THE NECK OF THE FEMUR\*

## DEVELOPMENT OF THE TREATMENT

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TO general practitioners the recent changes which have occurred in the treatment of fractures of the neck of the femur must present a confusing picture. It is our object, therefore, to present a concise account of the evolution of the various methods of treatment and to indicate their general usefulness from a clinical point of view.

Among the first to draw attention to fractures of the neck of the femur was Ambroise Paré.<sup>1</sup> Although the injury was potentially coexistent with man himself, it had not been recognized as a clinical entity by earlier surgeons and even the great Paré looked on the condition as a traumatic dislocation. It was only after repeated unsuccessful attempts to reduce what he believed to be a dislocated hip that he arrived at the correct diagnosis of fracture of the femoral neck and instituted treatment by longitudinal extension.

Two landmarks divide the treatment of fractures of the neck of the femur into three eras. Each of the last two eras has been remarkable for the introduction of a new conception of the care of patients affected by this injury and each has been accompanied by an equally remarkable improvement in the end results of treatment.

Fractures of the neck of the femur may have been recognized by the ancient Egyptians, although no direct evidence of this has as yet been found. The first period of our arbitrarily divided phase of treatment therefore begins with the dawn of time and ends with the enunciation of the Whitman method of treatment in 1905.<sup>31,32</sup> The second period lasted from 1905 until

1931, and the third began with the general acceptance of internal fixation as the method of choice in the treatment of these fractures. This form of treatment still holds the field today among leading orthopedic surgeons.

The Edwin Smith<sup>5</sup> and Ebers<sup>6</sup> papyri are the earliest medical records, and it is to these that we must refer if we desire to have accurate information as to various methods of treating fractures in vogue during the first period. In the light of the means at their disposal the ancient Egyptians treated fractures excellently. Three forms of splinting were in everyday use: (1) Paired, bark splints padded with linen and moulded to the part. Retention of the splint was secured by bandages or linen ties. They were comfortable, secured rest of the part, and if their almost total absence from the Egyptian tombs is a criterion, gave excellent results. (2) The second variety might be considered the primordial ancestor of the present-day plaster cast. It was formed by the impregnation of several layers of linen by glue or resins and, while still soft, was moulded to the limb. It hardened to form an accurate mould of the affected part. A thousand years later we find that Hippocrates still used the same materials. (3) A third type of splint was a simple wooden peg which was used to gag the mouth open during tetanic convulsions so that feeding might be carried out.

In the early centuries the Arabians used a mixture of lime and egg white for making casts but, by 1798, they were using plaster of Paris. Hubenthal introduced plaster casts into Europe, but it was the Dutch

\* Read in abstract before the meeting of the Watertown District Medical Society, Watertown, South Dakota, November 23, 1937.

army Surgeon, Mathijssen, who devised the plaster bandage in 1852. In France, splints of rushes were in use in the fifteenth and

finest piece of apparatus in our fracture equipment,"—a statement with which the present authors agree.

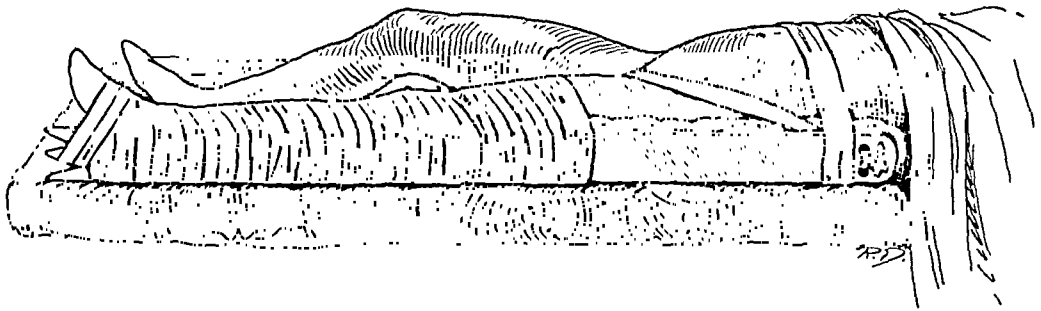


FIG. 1. Long Liston splint.

sixteenth centuries; in Japan and China, bamboo was requisitioned for a similar purpose because of its lightness, strength and durability. In times of war, necessity led to the use of a musket as a splint or crutch. From this it was but a step to the long Liston splint which provided not only for immobilization, but at the same time conserved the length of the limb. This splint consisted of a long wooden board, of sufficient length and breadth, which extended from the lower ribs to 4 inches beyond the foot. The first step in the application was to bind the leg to the splint and then, with the last turn or two of the bandage round the forked extremity of the splint, to secure the foot in good position. By means of a binder or bandage the splint was bound to the body and to the upper part of the thigh. Extension was obtained by means of a perineal band, which passed through two holes in the upper end of the splint in such a manner that, by tightening the band over the fixed perineum, the splint and leg could be pushed downward and so produce reduction. (Fig. 1.)

In 1850, Hugh Owen Thomas devised his hip and knee splints, a boon to all later surgeons. Seventy-seven years later, Meurice Sinclair stated that this (the Thomas splint and its modifications) had been directly responsible for the design of the majority of splints for the arm and leg which were used successfully in the World War. He added that it was "by far the

In spite of the appliances designed and the methods advocated in treatment, however, the general outlook regarding fractures of the hip in the latter part of the nineteenth century was gloomy in the extreme. As an index of the attitude of even the very elect in the profession toward fractures of the neck of the femur we can do no better than quote Sir Astley Cooper's own words: "Baffled in our various attempts at curing these cases, and finding the life of the patient occasionally sacrificed under the trials made to unite them, I should, if I sustained this accident in my own person, direct that a pillow should be placed under the limb throughout its length and that another should be rolled up under the knee, and that the limb should be thus extended until the inflammation and pain be subdued. I should then daily rise and sit in a high chair in order to prevent a degree of flexion which would be painful, and, walking with crutches, bear gently on the foot at first, then gradually more and more until the ligaments became thickened and the muscles increased in their power. A high-heeled boot should be next employed by which the halt would be much diminished." Such a statement from a man of Sir Astley Cooper's high professional standing meant that the most one could hope for was union by fibrous tissue, but at least one could avoid untimely death. In those days, and up until twenty-five years ago, every surgeon's purpose with respect to the treatment of fractures

was: (1) save the life of the patient, (2) obtain union, and (3) obtain good union. This was nowhere truer than in the case of fractures of the neck of the femur.

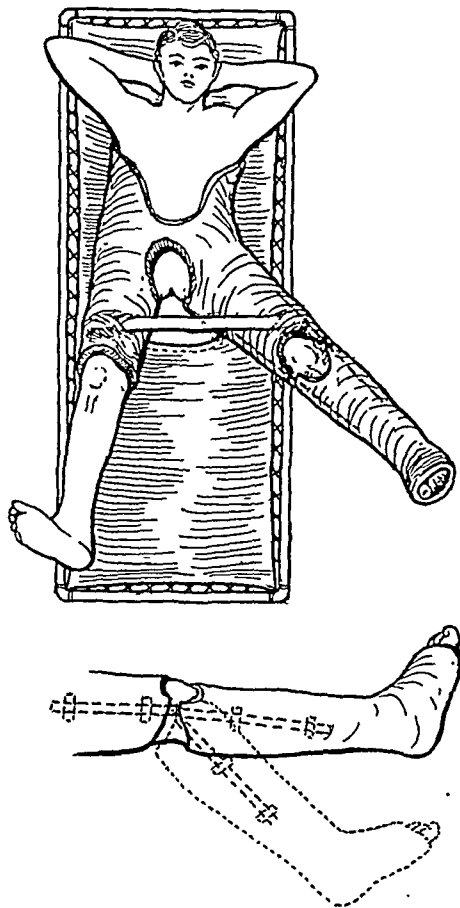


FIG. 2. Modified Whitman knee cast with hinge (Meyerding) at the knee joint.

Agnew, in 1878, in attempting to strike an optimistic note, succeeded only in intensifying the pessimistic attitude which was prevalent at the time. Speaking of the results of treating intracapsular fractures by the Astley Cooper method, he said: "There have been recorded a sufficient number of cases of bony union, after what was believed to be intracapsular fracture, to justify a hope that some of the cases encountered by the surgeon may have a similar termination." The doubt which surrounded the possibility of the healing of intracapsular fracture was widespread throughout Europe and claims of union were accepted *cum granum salis*.

Jonathan Hutchinson (1828-1913) in his description of the specimen of intracapsular fracture in the Pathological Museum of Leeds Hospital, wrote: "This specimen is alluded to by Malgaigne and Hamilton as if it were of doubtful validity, but neither of them had probably seen it. I cannot but hope that the publication of these life-sized drawings of the bone will set at rest all scepticism as to the possible union of intracapsular fractures. I trust, also, that it may lead to greater hopefulness in the treatment of those accidents and thus more systematic care in securing coaptation."

Indeed, so bad had the results of treatment been that men of the highest professional attainments had gradually come to regard all forms of active treatment as useless and in consequence had abandoned even the accepted methods of the day. This attitude of the profession prevailed to a great extent until 1905 when Royal Whitman introduced his method of fixation in plaster in wide abduction and internal rotation: "The patient, having been anesthetized, is placed on a pelvic support with a perineal bar, the shoulders resting on a box of equal height. Two assistants make manual traction on the extended limbs, drawing the perineum firmly against the bar and completely reducing the shortening on the injured side, the surgeon meanwhile lifting the thigh upwards if it is below the place of its fellow. The limb is then rotated slightly inwards, thus completely apposing the fragments. Both limbs, extended and under manual traction, are then abducted to the full limit, on the sound side first, to demonstrate the normal range, which varies in different individuals, and to balance the pelvis. When this limit is approached on the injured side, tension on the capsule assures the alignment of the fragments and forces a resistant contact. A long plaster spica extending from the axilla to the toes is then applied, which by fixing the limb in complete abduction, full extension, and slight inward rotation, assures the security

of the internal splinting. The knee is slightly flexed and the foot at a right angle with the leg slightly adducted."

Leadbetter modified this technique by reducing the fracture by perpendicular traction with the thigh flexed to a right angle; abduction and internal rotation followed. One important point in his method was his test for reduction. Reduction was complete when the affected foot remained upright on the palm of the examiner's hand. If external rotation occurred, reduction was incomplete and the maneuver had to be repeated. More recently (1936), Kleinberg, a former associate of Whitman, while adopting the Leadbetter technique, has modified the subsequent procedure by allowing patients, and one might almost say "forcing" patients, to get up on the third or fourth day and make attempts at walking. He claimed that by bearing weight on the affected leg, local union was not only encouraged but hastened.

There is no gainsaying the fact that union occurs in the cases of some old and frail individuals, but we believe that the last word has not been said on the subject of nonunion, its causes and its cure. We are convinced of the fact that old age per se is not the cause of nonunion any more than the fact that a patient has passed his allotted span makes him of necessity a poor surgical risk. We have treated patients in the seventh and eighth decades of life who have recovered from the effects of trauma which even in the robust and vigorous could have been adequate to produce death from shock. While the method employed in obtaining reduction of the fragments varies with the individual surgeon, means must be taken which will permit of reduction being maintained and at the same time prevent the development of pressure sores and hypostatic pneumonia. By the use of the plaster cast this is possible. The patient may be moved into any position or even transported in comfort. The stiffness of the knee so commonly met with in these elderly, often arthritic, patients

following prolonged fixation in the Whitman cast can be prevented by employing a certain type of knee hinge in the cast as described by Meyerding. (Fig. 2.)

A commission appointed by the American Orthopedic Association to study the end results of the Whitman treatment of intracapsular fractures of the neck of the femur reported in October, 1930 that 50 per cent of patients under the age of 60 could look forward to solid bony union, but that the percentage of union in those more than 60 years of age was distinctly lower. While all credit must go to Royal Whitman for his excellent practice and advocacy of the abduction and fixation treatment, we must concede a modicum of praise to Hennequin and to Newton Schafer who were probably the first in the field to use the method. In 1927, Cotton advised artificial impaction by means of a mallet following reduction as a means whereby union could be made more certain.

In 1850, Lagenbeck made the first attempt to treat fractures surgically by internal fixation. He used a silver drill to unite the fragments, but old age and "hospital gangrene" unfortunately defeated his ingenuity and surgical heroism. Lister, some years later, made a similar attempt. The details given of the operation were insufficient and we are not certain that the fragments were pegged. Patients survived but union by fibrous tissue alone was obtained. If the fragments were not pegged, this was probably the first occasion on which drilling of the head and neck of the femur was carried out.

The first report of a successful case was published by König in 1878. The patient was a young and vigorous man who was operated on under aseptic conditions through a small lateral incision over the greater trochanter. Between 1878 and the adoption of the more modern forms of internal fixation much work was done in this field. Murphy and Beckman in this country and MacLennan in Scotland used ordinary nails and screws, with variable success. Bone pegs of the intramedullary



FIG. 3. Showing Smith-Peterson nail in place.



FIG. 4 Showing the lag screw (as described by Henderson).

variety, or bonegrafting operations in which the tibia and fibula were used, have been employed and advocated by Albee, Henderson,<sup>13</sup> and Campbell although these procedures have a greater sphere of usefulness in the treatment of ununited old fractures of the femoral neck. The nail used originally by Smith-Petersen was a solid one and the difficulty of introducing it was considerable, necessitating arthrotomy if accurate placing in the head of the femur was to be secured. With the modification suggested independently by Johansson in Sweden, King in Melbourne, and Henderson<sup>12</sup> at The Mayo Clinic, whereby a cannulated nail was used, the difficulty of introduction and the severity of the operation were immensely reduced.

In all our surgical treatment the fracture was reduced by simple Buck's (1861) extension or by either the Whitman or Leadbetter maneuvers. The accuracy of the reduction was checked by anteroposterior and lateral roentgenograms. The modern use of roentgenograms permits of accurate determination of the position of the fragments following attempts at reduction and before internal fixation is employed. This, performed under spinal anesthesia, and by a surgical team experienced in the technique, results in a lessened mortality rate. A Kirschner wire was then introduced, through a small lateral incision centered over the lower border of the greater trochanter, by drilling up through the neck into the head. Localization of the wire could be accurately determined by films or fluoroscopic examination. The Smith-Petersen nail was then slipped over the wire and driven home through the femoral neck and into the head. The immediate and late effects, while excellent, were not perfect, but the percentage of good end results was definitely increased for all ages and a new day had dawned for the unhappy sufferer from this type of fracture. (Fig. 3.)

There are two disadvantages, however, to the use of the Smith-Petersen nail: (1) in some cases it slips out; (2) in inserting

the nail, separation of the fragments may occur so that impaction subsequently is necessary. To overcome these defects Henderson<sup>11,12</sup> suggested the use of the lag screw. This screw has been in use among furniture makers for many years and is mechanically adapted to overcome just these disadvantages. The method of introduction is similar in all respects, but there are a few points upon which Henderson lays special emphasis: No attempt at manipulative reduction has been necessary since reduction has been accomplished in all cases by Buck's extension.

We believe in waiting until a week has elapsed following injury before surgical intervention is undertaken, even though no displacement has occurred. The advantages gained from this procedure outweigh anything that may be lost by waiting. Shock has been combated, the vital forces of the aged and frail have been fortified, and the possibility of an undiscovered yet potentially great surgical risk eliminated. Deaths which occur during this period of waiting can, therefore, be accurately classified as being due to primary shock or debility and not used as reasons for discrediting an otherwise life-saving surgical procedure.

With accurate coaptation of the fractured ends, confirmed roentgenologically, and with the lower border of the greater trochanter exposed through a small lateral incision, a Kirschner wire is run into the femoral neck and through the head until it impinges on the acetabular wall. No trouble results from this minor trauma to the articular cartilage and a firmly fixed proximal fragment is obtained which renders the subsequent steps partially to drill the neck and head simple and accurate. The insertion of the lag screw along the Kirschner wire is straightforward. When it is well buried in the head, the covering sleeve is introduced by special instruments and tightened down upon the screw and, as this occurs, the fragments are drawn together so that firm and accurate coaptation is obtained. No retention plaster cast

is required—a simple foot splint with a cross bar being adequate to prevent external rotation of the leg. (Fig. 4.)

Within two weeks flexion movements at the hip by means of a knee sling are begun but, later on, are carried out actively. The patient is allowed up in six weeks on crutches, although weight-bearing is not attempted until after the third month. Ordinarily we believe that removal of the screw in about four months prevents excessive absorption of the neck of the femur and, by removing a foreign body, militates against subsequent trouble and electrolytic reaction. In the series of cases at The Mayo Clinic in which treatment was conducted by this method, bony union occurred with excellent functional results in about 72 per cent.

Today, each orthopedic surgeon follows the method which appears to him to be the most effective, and whether it be that entailing the use of a Smith-Petersen nail, a Henderson lag screw, Moore's pins, or Martin's screws, in the hands of a capable man the end results are considerably better than those which followed the older forms of simple fixation. It is no simple matter to insert a nail with certainty, and many have been the devices tried to render this primary operative step one of mathematical accuracy. Valls of Buenos Aires and Hey-Groves of Bristol have devised ingenious inserters which make the operative technique simpler.

#### SUMMARY

The subject of fracture of the neck of the femur has been reviewed from its recognition at the time of Ambroise Paré, through the period of the epoch making changes introduced by Whitman, up to the modern method of internal fixation.

In cases of fresh fracture of the neck of the femur the use of the Smith-Petersen nail and of the Henderson lag screw, under the control of Roentgen rays, has resulted in accurate reposition of the fragments and their complete fixation, with subse-

quent bony union in 72 per cent of cases. The excellent results which have been obtained by modern treatment of this most disabling and crippling condition have changed the pessimistic attitude, with which the profession as a whole regarded this injury in the late nineteenth century to the one of present day optimism.

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WE understand physical pain aright only when we realise the part played by the individual in a system morphologically the same for everyone, when we have analysed . . . *living* pain.  
 From—"Surgery of Pain" by René Leriche (Williams & Wilkins).



# TREATMENT OF DELAYED OR NON-UNION BY BONE DRILLING

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**D**URING 1937 330 fractures of the tibia (excluding Pott's fractures involving the medial malleolus)

of the fragments at initial reduction; (2) remanipulation due to slipping of the fragments; and (3) the fact that some were compound.

In our experience a compound fracture usually is slower to unite than a simple one. One probable explanation is the loss of blood which is a simple fracture, remains as a hematoma around the fracture site and possibly serves as a medium for invading osteoid tissue and aids in the liberation of phosphatase (which is considered essential in the deposition of calcium<sup>1</sup>). Contrary to popular opinion, the age of the patient has no relation to nonunion; in our eight cases the age varied from 20 to 69.

In our experience the repair of fractures of the shaft of the tibia usually requires twelve to fourteen weeks of immobilization, and some cases require an even longer time. Usually, however, weight-bearing in a non-padded "skin" cast with an iron walking caliper has promoted union when it did not appear likely to occur after three months. This régime has been successful in all but eight cases, in which the fragments were drilled. Previously, such cases underwent surgical intervention in which either bone grafting, resection of the fibrous union, or plating was done. In the past year, since we resorted to bone drilling, not a single bone graft or similar procedure has been necessary for nonunion of the tibia.

The treatment of nonunion by bone drilling was first proposed by A. Beck<sup>2</sup> of Kiel, and described by Lorenz Böhler<sup>3</sup> of Vienna. Apparently this procedure is not generally recognized in this country, as few references commending it are found in the literature. This principle has been used, however, for treatment in fractures of the neck of the femur and Legg-Perthe's disease,<sup>4</sup> ununited fractures of carpal bones,<sup>5</sup> and recently a series of cases of the long bones.<sup>6</sup>



FIG. 1. Case III. Mid-thigh non-padded cast with iron walking caliper, applied after bone drilling.

were treated at St. Louis City Hospital. Of this number eight, or 2.4 per cent, were considered to be cases of delayed union or potential nonunion. No apparent mechanical factors were involved, such as interposition of fascia or muscle between the fragments, nor was there any derangement of the calcium metabolism as far as could be determined by blood chemistry.

The probable causes of the delayed union in these cases were: (1) poor approximation

The indications for drilling are: persistent mobility after adequate immobilization, as detected clinically; lack of new

bone formation bridging the fracture site, as determined by x-ray. The contraindications are the same as for any bone surgical procedure. We prefer to confine the drilling to the bones of the leg or lower thigh, because there is less possibility of injuring other important structures than in the arm. We do not wait so long as we formerly

did before resorting to drilling the fragments, as it is known that prolonged maintenance of the fragments in poor

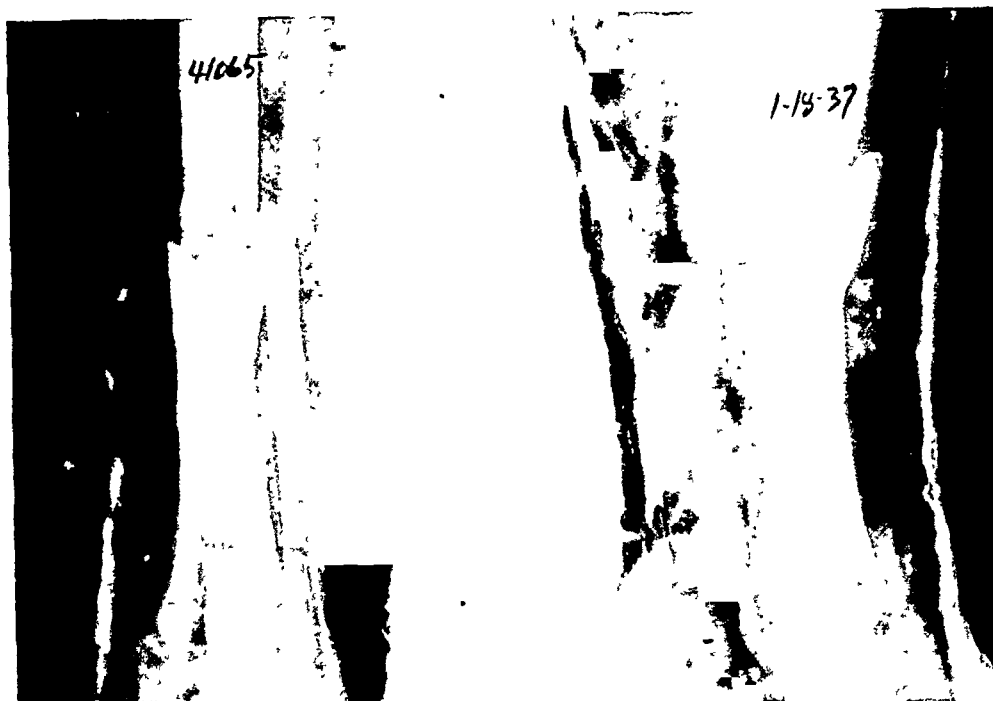


FIG. 2. Case III. Mid-third of tibia with nonunion after twenty-nine weeks immobilization in cast.

bone formation bridging the fracture site, as determined by x-ray. The contraindications are the same as for any bone surgical procedure. We prefer to confine the drilling to the bones of the leg or lower thigh, because there is less possibility of injuring other important structures than in the arm. We do not wait so long as we formerly

alignment prevents an early return to normal function.

Bone drilling is done in the fluoroscopy room. However, although the fluoroscope is helpful, it is not necessary. The skin over the nonunion is prepared with iodine and alcohol, and infiltrated with novocaine ( $\frac{1}{2}$  per cent). The periosteum must also be

TABLE I

Site of Fracture	Age	Time of Immobilization, Weeks	Possible Cause of Nonunion	Time of Immobilization after Drilling before Union Occurred, Weeks
Junction mid and distal third of tibia .. . . .	69	24	Compound	4
Mid third of tibia.....	23	18	Undetermined	4
Mid third of tibia .....	20	29	Undetermined	4
Junction mid and distal thirds of tibia .. . . .	21	17	Poor reduction	5
Junction mid and distal third of tibia.....	48	28	Compound	5
Junction mid and distal third of tibia .. . . .	40	42	Remanipulation three times	5
Distal third of femur.....	62	63	Poor approximation and compound	6
Mid third of tibia.....	69	17	Remanipulation twice	9
Mid third of tibia.....	54	12	Poor approximation	8

injected carefully or the patient will complain. Two or three puncture wounds are made over the proximal and distal

the fractures which were (1) not accurately reduced, (2) re-manipulated, or (3) compounded.



FIG. 3. End result of same case after drilling. New bone had formed, and fracture was clinically solid in four weeks. Patient allowed full weight bearing after two months.

fragments adjacent to the fracture site, about  $\frac{1}{2}$  inch apart, through which the drill is inserted. Eight to ten holes are then drilled obliquely into the bone with a  $\frac{3}{16}$  inch drill, in such a way as to traverse both fragments with each drilling. This is easily done in spiral or oblique fractures, but in transverse fractures more care is required. A non-padded ambulatory plaster cast with an iron walking caliper is applied over a sterile dressing. The patient is encouraged to walk on the cast the next day, after the plaster is dry and the slight pain has subsided.

Table I shows the results of eight cases of nonunion of the tibia and one of the distal third of the femur.

#### CONCLUSIONS

Delayed or nonunion is not uncommon in fractures of the shaft of the tibia, and seems to follow more frequently

Bone drilling in such cases offers a simple method of promoting union, and has supplanted major surgical procedures for delayed or nonunion of the tibia in the St. Louis City Hospital.

Eight patients so treated required solid union clinically, and the x-ray revealed new bone formation within a few weeks.

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# THE USE OF REGIONAL NERVE BLOCK DURING TREATMENT FOR FRACTURED RIBS\*

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**F**RACTURE of the ribs, in the large majority of cases, is within easy management. Uncomplicated fractures may be treated by simple adhesive strapping for immobilization of the rib fragments. Such therapy usually terminates favorably within three to four weeks. The most annoying complication during such treatment is pain. Adhesive strapping may serve well to maintain proper alignment of the broken bone fragments and to diminish respiratory movements of the chest, but it will not entirely eliminate motion. With motion some degree of pain will regularly be present at the site of fracture.

Pain may be only an annoying disturbance during healing of rib fractures, but it can be the primary cause of more serious sequelae. The more serious complications following simple fracture of the ribs are respiratory infections. Most of the few patients with simple rib fracture terminating fatally, die from pneumonia. The incidence is fairly high in the aged. Maingot has often observed pneumonia following the fracture of one or two ribs in elderly patients.<sup>1</sup> Ten Horn also found pneumonia responsible for most deaths after fracture of the ribs. In elderly individuals, he recommends that no attempt be made to immobilize the chest mechanically. His main reliance is on morphine given in large doses and repeated often enough to control the pain. He insists, "that morphine in addition to relieving the pain, permits the respirations to proceed unhampered and reduces the need for oxygen, but its great-

est benefit is the prophylaxis against pneumonia by allowing coughing without pain."<sup>2</sup> Pain may continue for a considerable time after the fracture of a rib. Persistent pain is most often callus pain.<sup>3</sup> Rarely is it a generalized intercostal neuralgia although the latter is sometimes reported. Regardless of the cause, as long as pain is present at or near the site of fractured ribs the patient is more likely to develop pneumonia than would be true were the pain relieved.

Extensive fractures, those involving several ribs, and those complicated by much overlapping of fragments, traumatic pleurisy, hemorrhage, tension pneumothorax, emphysema of the skin, etc., present therapeutic indications entirely different from simple fractures. It also follows that in this group an unfavorable issue is not uncommon. In severe crushing injuries of the chest, even those without severe hemorrhage or torn lung, the mortality is very high.<sup>4</sup> Fatalities, when they occur several days after the injury, are often due to pneumonia. In patients with extensive or complicated rib fracture severe pain is regularly a persistent complication. In this group pain becomes a complication of major importance and it has a definite bearing upon the mortality. Because of the severe pain these patients put forth every effort to eliminate any activity that will increase their discomfort. Coughing is suppressed, movements that involve the trunk are not undertaken, and deep breathing is avoided. Respiratory effort may be so

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retarded that the involved chest is practically splinted. It has been observed that actual massive collapse of the lung may follow such forced inactivity. It regularly happens that the application of plaster bandage or even a cast fails to alleviate the pain and sedatives or hypnotics must be administered.

Since pain may play such an important rôle in mortality following severe trauma to the chest, it seems logical to attempt the relief of pain early in the treatment. It has been pointed out that the control of pain or adequate sedation, in an amount that will not seriously depress respirations, is necessary in chest wounds requiring operative intervention.<sup>5</sup> Generous amounts of morphine or other opiates are frequently given. Their use is not advised although their favorable effect upon pain is fully realized. The relief of pain in traumatic chests has for its therapeutic usefulness not only alleviation of the patient's discomfort but also the more important objective, prophylaxis against serious or fatal pulmonary complications. To serve this purpose it is necessary that the patient increase the ventilation of his lungs by deep breathing and that the lower respiratory tract be kept free from secretions by coughing. The opiates do not favor increased ventilation or vigorous coughing. The depression of respiration that follows the large amounts of these drugs required adequately to relieve the severe pain accompanying chest injuries, decreases ventilation of the lungs and seriously impairs the cough reflex. A more logical method for pain relief is the interruption of painful stimuli along their nervous pathways. The use of regional nerve block provides a means of adequate therapy for pain. It is without the objections raised against the opiates. It is obvious of course, that such a therapeutic measure as nerve block is no substitute for surgical therapy in cases with severe pleuropulmonary injuries but should be employed only as an adjunct.

Regional anesthesia designed to control pain should be directed toward paralyzing

the nerves supplying the site of painful stimuli. With pain arising from a fractured rib, the intercostal nerve corresponding to the involved rib would immediately be suggested for injection. The injection of a single intercostal nerve does not invariably produce complete anesthesia along the entire course of the corresponding rib. The depression of painful stimuli may be so profound that complete relief is obtained or it may follow that accessory filaments from contiguous nerves will prevent more than a lessened pain response. To insure insensibility over the entire extent of a fractured rib it may frequently be necessary to inject not only the nerve corresponding to the fractured bone but also the nerves above and below the injured rib when intercostal block is employed. The use of paravertebral nerve block will more nearly insure complete pain relief.

The technique for paravertebral injection of thoracic nerves is not complicated. Excellent descriptions of the recommended procedures are given by Labat.<sup>6</sup> The technique employed here is essentially that described by Labat as his technique No. 1. The patient is placed upon the uninjured side and the knees flexed so as to widen the intercostal spaces. The spinous processes of the dorsal vertebrae are defined. Opposite each spinous process corresponding to the intercostal space selected for injection, a skin wheal is raised with procaine solution. The distance of the wheal from the midline varies from 4 to 5 cm. depending upon the width of the patient's back. An 8 or 10 cm. small gauge needle unattached to the syringe is introduced through the wheal and advanced at right angles with the skin surface so as to contact the rib just above the intercostal space to be injected. The rib is contacted and the needle is slightly withdrawn so that its direction may be changed. The syringe end of the needle is inclined outward and upward until the angle formed between the skin surface and the shaft of the needle is approximately 45 degrees. It is then advanced about 1 cm. downward and

inward toward the lower border of the rib. The lower border of the rib is reached by the point of the needle with this maneuver and it is possible by slightly changing the direction downward to feel the needle slip off the rib. With the point of the needle located just below the rib it is advanced inward and downward across the intercostal space, a distance of approximately 2 cm., where it impinges upon the body of the vertebra. The syringe is then attached and injection of the anesthetic solution begun after withdrawing the needle a very short distance from the bony surface and carefully performing the aspiration test.

The dangers of this procedure have been described by some as those attending puncture of the pleural cavity, the lung, an intercostal blood vessel or the subarachnoid space. None of these accidents should result in serious complications and their occurrence is not common. Puncturing the pleural cavity with a small needle will produce no serious complication and injection of solutions will do little more than induce coughing. Pneumothorax is unlikely to follow unless the pleura is torn and an aperture larger than that produced by a needle puncture is made. It is advisable to inject very slowly at the start and if coughing is induced, stop the injection until the needle can be properly placed. If the needle is inadvertently inserted into lung tissue, blood will follow the aspiration test. Injecting a small amount of anesthetic solution into the lung causes little more than a bitter taste in the patient's mouth. If an intercostal blood vessel is punctured, blood will be aspirated from the needle. The small hematoma that will be created, after puncture with the fine needle used for nerve blocking, is without significance. Although it is practically impossible to introduce a needle through an intervertebral foramen when the described technique is followed, occasionally cerebrospinal fluid is aspirated after the needle is put in place. The explanation for such an occurrence is the puncture of an abnormal prolongation

of the subarachnoid cul-de-sac accompanying the nerve beyond the intervertebral foramen. If the technique is carefully followed and the aspiration test in two planes completely carried out and frequently repeated the dangers accompanying paravertebral nerve block are remote.

One per cent solution of procaine hydrochloride is recommended for paravertebral nerve block. Five to 6 c.c. may be placed at each site of injection. Stronger solutions may be too toxic when a considerable amount is used to secure extensive anesthesia. Weaker solutions, to be effective, must be injected in volumes too large for convenience. Five or 6 c.c. of fluid diffuse in the intercostal space and comes into contact with both anterior and posterior primary divisions of the nerve as well as the communicating rami.

When alcohol is to be injected it should always be preceded by the procaine block as described, but with a smaller amount of solution. Three or 4 c.c. of 1 per cent procaine solution will be sufficient. The alcohol should be injected fifteen to twenty minutes later. The position of the patient and of the needle should not be changed during the interval between injections. The initial injection of procaine will produce an anesthetized area upon which to place the temporarily irritating alcohol and its rapid absorption will eliminate diluting the alcoholic solution so that it may not be of maximum effectiveness. With this technique 1 c.c. of 95 per cent or absolute alcohol gives satisfactory results. More than 2 c.c. of alcohol should not be needed if properly placed and this amount should never be exceeded.

Aside from those complications already discussed, that may follow during the technical procedure of thoracic paravertebral anesthesia and those resulting from errors in technique, no serious objections other than those relating to the toxicity of procaine have been advanced. When alcohol is employed pleural irritation from injury with the needle, together with an inflammatory reaction caused by the

alcohol, will infrequently follow the injection. The predominating symptom is a burning pain which is noticed at about the time anesthesia from the procaine is lost. A small minority of patients may develop irritation neuritis of the somatic nerves. Such a neuritis may occur at any time for a week after injection and varies greatly in intensity. Either complication may be satisfactorily treated by procaine infiltration of the nerves which are distributed to the thoracic segments involved.<sup>7</sup> Hydrothorax, due to pleural irritation from alcohol, has been reported as a rare complication.<sup>8</sup> The contention that intercostal nerves are permanently destroyed with alcohol is not supported clinically or experimentally. The paralysis is transitory and seldom exceeds two or three weeks. The fine sympathetic rami may not regain function.<sup>9</sup> The possibility of further tissue injury from broken bone fragments in painless areas may be obviated by strapping or the application of a light cast which should be a regular part of the treatment. It has been demonstrated by Latteri<sup>10</sup> that the use of alcoholic injections during treatment of fractured ribs in no way affects the formation and progress of the callus or the proper healing of the fracture.

Paravertebral nerve block has recently been employed here in the treatment of crushing injuries of the chest. Thirteen patients with severely complicated rib fractures have been treated. Without exception these patients were admitted to the hospital by ambulance and were considered serious emergencies. For each of them prognosis was reserved until the extent of the respiratory complications might be determined following several days' hospitalization. The fractures involved from one to ten ribs, and five of the patients had accompanying fractures of other bones. Pulmonary complications included consolidation, atelectasis, tension and hemothorax, subcutaneous emphysema, hemorrhage and various other pleuropulmonary injuries. Cyanosis, dyspnea and orthopnea were usually present at the time

of admission. Severe, continuous pain was a prominent symptom of every patient.

Paravertebral injections of anesthetic solutions was accomplished soon after a diagnosis of the extent of the injury was tentatively made. The early cases received procaine block. Patients with fracture of three ribs or less were injected with a 2 per cent solution. When more extensive block was required, 1 per cent solutions were employed. The therapeutic results of regional anesthesia were immediate and of definite usefulness. Pain was completely relieved for eight of the patients, suppressed to the extent that ordinary breathing was not uncomfortable for four more, and made less severe for one individual. Following the anesthetic nerve block each of the patients could be moved about without serious complaint and would carry out instructions to breath deeply and cough. The duration of pain relief from procaine injections varied from three to twelve hours. It was the practice, with the first use of this therapy, to repeat the nerve block with the return of pain. Later cases received alcohol following the technique already described. One patient had five treatments with procaine. No patient receiving alcohol required more than one nerve block.

Two of the thirteen treated patients died as a result of complications from their injury. One expired on the seventh day after admission. This patient had fractures of both femurs, and the left ulna, lacerations of the spleen and left kidney and extensive bronchopneumonia. Another died on the eighteenth day after accident. Autopsy revealed lacerations of the lung, pulmonary emboli and hemorrhage of the lesser omental sac.

The results that may follow nerve block procedures during treatment of fractured ribs are illustrated by the two following cases. These cases are selected as the two most favorable results in the brief series reported.

CASE 1. A white male, age 38, entered the hospital from the ambulance with marked

emphysema and external evidence of injury to the left chest. There was profuse epistaxis. The accident had occurred the day before admission. The diagnosis was multiple rib fractures (third to ninth inclusive) on the left side, subcutaneous emphysema on the left from neck to scrotum, and consolidation of the right chest. The patient was in severe pain, very cyanotic, dyspneic and orthopneic. He would not cough or tolerate moving because of the pain. Oxygen therapy and a moderate amount of morphine did not improve the condition. A paravertebral procaine block was completed on the left side to include the third to eleventh thoracic nerves. Pain relief was immediate and complete. The patient coughed freely, was moved from side to side and the consolidation in the right chest could no longer be diagnosed with certainty. The cyanosis cleared and breathing assumed a normal character. Severe pain returned after sixteen hours. The procaine injection was repeated and again gave complete relief. After eight hours a third block was done. Thereafter pain was not a prominent symptom. X-ray examinations then revealed "irregular patches of pneumonitis in the right thorax." Recovery was complete in five weeks.

CASE II. A white male, age 60, was admitted from the ambulance at noon. He had been injured at 4 A.M. He was cyanotic and dyspneic with subcutaneous emphysema from the clavicle to the lower chest on the left side. The left ribs (sixth to ninth inclusive) were fractured in the midaxillary line. There was evidence of hemopneumothorax of the left chest. Late on the day of admission the temperature was 102 degrees and cyanosis and dyspnea were more severe despite oxygen therapy. Examination revealed signs of "atelectasis or bronchopneumonia of the right lower lobe posteriorly, related to stasis of secretions." Pain was severe and deep breathing or coughing was suppressed. A left paravertebral nerve block was performed with procaine to include the fifth to the tenth thoracic nerves. The pain was immediately eliminated and cyanosis and dyspnea were relieved. The patient was turned to the right side and coughed vigorously without severe discomfort. He was comfortable throughout the night. The anesthesia was repeated on the following morning when less severe pain had returned. Another block was done in the late evening. There was no complaint of severe pain at the fracture site after

the third block but forced coughing caused some discomfort. More than 300 c.c. of blood was removed from the left chest. Seven days after injury, examination revealed "a residual hemopneumothorax and resolving bronchopneumonia progressing favorably." Recovery was complete.

No reference has been found to the use of paravertebral nerve block for the relief of pain from fractured ribs. Intercostal nerve block has been employed for ambulatory patients during the treatment of uncomplicated rib fracture. Leotta has treated pain associated with tuberculosis by alcohol injection of the involved intercostal nerves.<sup>11</sup> His technique was applied successfully in four cases of rib fracture by Latteri.<sup>10</sup> Grieco selected a group of uncomplicated cases of rib fracture which ordinarily would be treated ambulatorily. Patients were chosen in whom pain was persistent despite immobilization by adhesive strapping. He concluded after treating ten patients that intercostal nerve block with alcohol afforded quick relief from pain and considerably shortened the period of disability.<sup>12</sup> The same therapeutic procedure was used by Rabboni to treat ten ambulatory patients.<sup>13</sup> Pain relief was obtained for each individual treated and nothing developed to complicate the initial lesion or its treatment. Zoppi has recommended the daily subcutaneous injection of procaine at the site of fractured ribs to allay pain and eliminate the use of morphine.<sup>14</sup> The experience here has not included the treatment of ambulatory patients with paravertebral block, but the favorable effect upon pain for non-ambulatory patients, the simplicity of the technique and absence of complications definitely recommend it.

#### SUMMARY

The treatment of simple and complicated fractures of the ribs should include some therapeutic medium for relieving the associated pain. The relief of pain is important for the patient's comfort. It is more important as prophylaxis against respiratory infections. Respiratory infections are re-



sponsible for the majority of deaths that follow these injuries.

The use of large amounts of opiates or narcotics to treat the pain associated with fractured ribs is not advised since adequate lung ventilation may be hindered and the stasis of secretions enhanced by depressing respirations and the cough reflex.

The use of paravertebral injections of procaine and alcohol at the site of the involved thoracic nerves is recommended. A technic for the convenient application of the regional nerve block is described.

Results following the treatment of thirteen hospitalized patients with serious, complicated injuries of the chest wall are reviewed. Two case reports are included.

The results indicate that the relief of pain following fractured ribs, by interrupting the nervous pathways with paravertebral injections of anesthetic solutions is a worthwhile therapeutic measure.

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# BODY SECTION RADIOGRAPHY IN SURGICAL CONDITIONS\*

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**B**ODY section radiography is an inclusive term applied to methods of radiographing a selected layer in the body to the exclusion, in greater or lesser degree, of other layers. This type of radiography can be done in several ways, all of which have specific terms,† stratigraphy, planigraphy, tomography, laminagraphy, and serioscopy. It seems desirable to restrict these specific terms to the particular method employed, or to the type of apparatus used, and to employ a general term to cover all of them. For a description of these several methods (except serioscopy), the reader is referred to the articles by Andrews,<sup>1</sup> Kieffer,<sup>2</sup> and Moore.<sup>3</sup> Because the principle is complex, a simple explanation of the fundamental basis of all the methods employed in body section radiography is in order.

If a source of visible light and a recording medium be revolved about a fixed axis, the shadow of any object in this axis will maintain a constant relationship to the light and the recording medium. Any object not directly in the axis, about which revolution takes place, will have a constantly shifting relationship which is dependent on its distance from the axis and its relationship to either the light or the recording medium. This is seen in the diagram. (Fig. 1.) The diagram illustrates the simplest form of movement whereby shadows of objects in alignment can be separated from each other. With combined movements, the separation of shadows can be made more effective.

† Stratigraphy, Vallebona; planigraphy Ziedses des Plantes; tomography, Chaoul and Grossmann; laminagraphy, Moore; serioscopy, Ziedses des Plantes and Cottenot.

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The rules which apply to visible light apply with equal force, but with a qualification, to x-light. This qualification will be referred to later. In radiography, the x-light records the sum of all structures capable of forming a shadow on the recording medium, the radiograph. Many maneuvers have been devised to separate superimposed shadows by changes of position of x-ray tube, film and object. All of them are of limited use. The first effort to eliminate undesired shadows by means of a coördinated movement of x-ray tube and medium, during exposure, was by Bocage in 1921. The investigations since that time can be found fully described in the references already given.

With visible light, the limitation in the separation of shadows has been referred to above. It is to be remembered, in shifting superimposed shadows with x-light, that a proportion of the shadows which are shifted is distributed throughout the path of travel of the beam of x-rays because of their penetrability. In consequence, the coördinated movement of x-ray tube and its recording medium, in addition to shifting shadows above and below the axis of movement, must also distribute them widely and evenly. The more mathematically harmonious and complete the movement of the x-ray tube and film, the better the distribution of the undesired shadows. The merits of the different movements employed in body section radiography need not otherwise be discussed here.

A selected level or layer in the body can be radiographed, to the greater or less exclusion of layers above and below, in three ways: through coördinated, synchro-

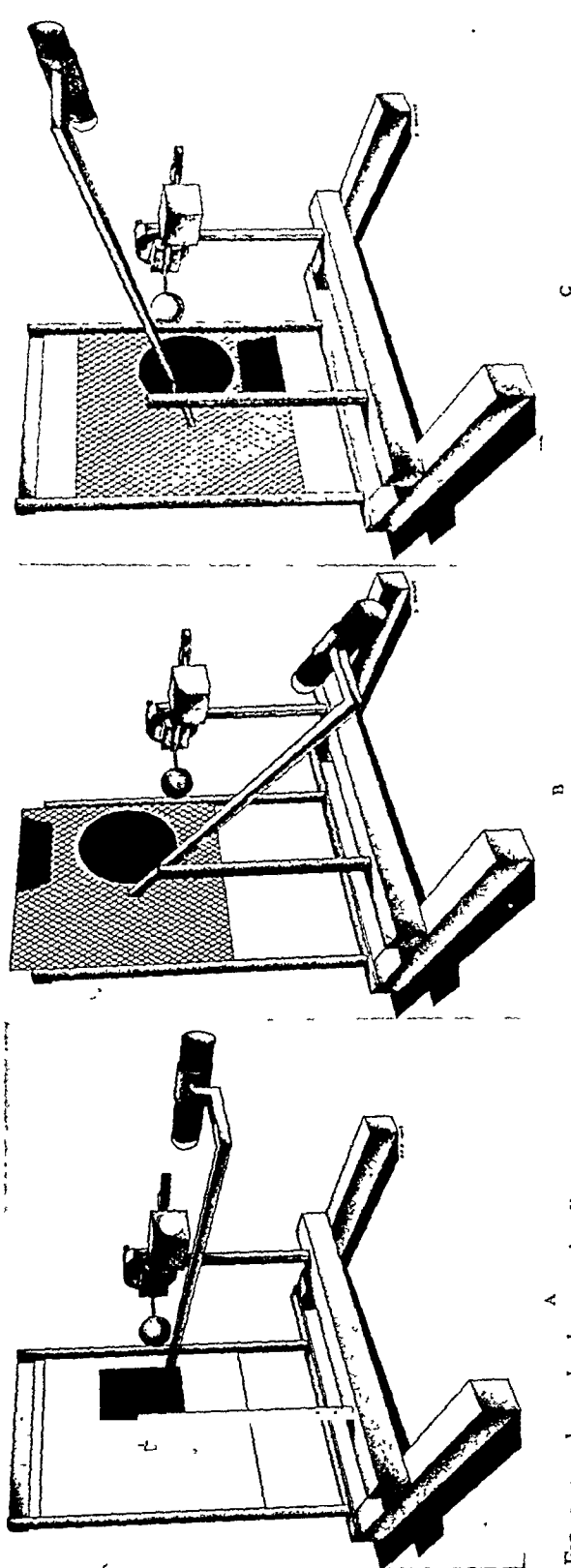


FIG. 1. A, cube and sphere are in alignment in a beam of light. Shadow of cube obliterates that of sphere on recording medium. B, beam of light and recording medium move on same axis as that of sphere; shadows of cube and sphere are separated. C, reverse of preceding movement.

nized movement in different directions of x-ray tube and film during exposure; by keeping the tube and film stationary and revolving the body—in Vallebona's stratigraphy the tube and film remain stationary and the object (the patient) is moved, which is the opposite principle to that in the other methods of body section radiography; and by making multiple radiographs at different angles, the tube, film and body being stationary. In the last case, the radiographs are moved over each other in a special apparatus devised for that purpose, the serioscope. The films are placed in the serioscope in the order in which they have been made. The movement imparted to them is in relationship to the angle at which they were exposed.

In all methods of body section radiography there are definite thicknesses of layer which can be recorded clearly. The thickness varies with the apparatus and the type and extent of excursion of tube and film. The laminagraph has most of the possible practical movements of tube and film, with the means of varying the thickness of the layer to be investigated, the lower limit being about 5 mm. Increasing this decreases clearness. The laminagraph can be used for serioscopy.

It is a general principle that body section radiography has its chief value where there is a maximum number of superimposed structures (Fig. 2) and, conversely, it is of less value where the opposite is the case. Unwanted shadows are displaced and dispersed by this means, but there is also great value in the fact that the shallow depth of layer permits minimal contrasts in density to be recorded on the film. (Fig. 3.) Finer changes in tissue, therefore, that otherwise would be undiscoverable, can be visualized; for example, small areas of calcification in soft tissues or small fragments of fractured bone, or foreign bodies of little density. Body section radiography, therefore, has its chief use in regions or conditions where standard x-ray practice is inapplicable.

It is to be borne in mind, however, that the limitations which apply to radiography, because of great size or massiveness of the

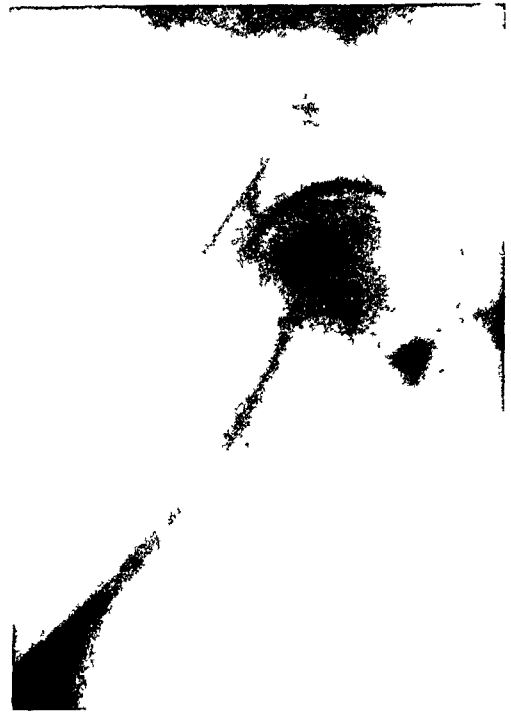


FIG. 2 Laminagraph of lateral view of normal hip joint through opposite hip joint.

part to be studied, cannot be overcome by any method of body section radiography and, as a corollary to this, it must be stated that, so far as experience has gone, laminagraphy is an adjunct to, and not a supersession of, conventional methods.

#### RESPIRATORY SYSTEM

Body section radiography is of the utmost value throughout the respiratory tract. This method has more applications in the lower part of the tract than in the upper air passages, for the lower part is subject to more pathologic states which can be investigated advantageously by any type of x-ray procedure. It does not promise ever to be very useful in acute or early chronic pulmonary disease. It may demonstrate, however, that the disease is more advanced than was thought to be the case by other methods of examination.

But this is not true in early tracheobronchial disease, as there is great promise

of valuable aid from this method in early disease, especially of an occlusal type. In the normal respiratory tract, the larger bronchial branches and likewise their narrowing and occlusion. In the case of a pulmonary cavity, its depth is accurately

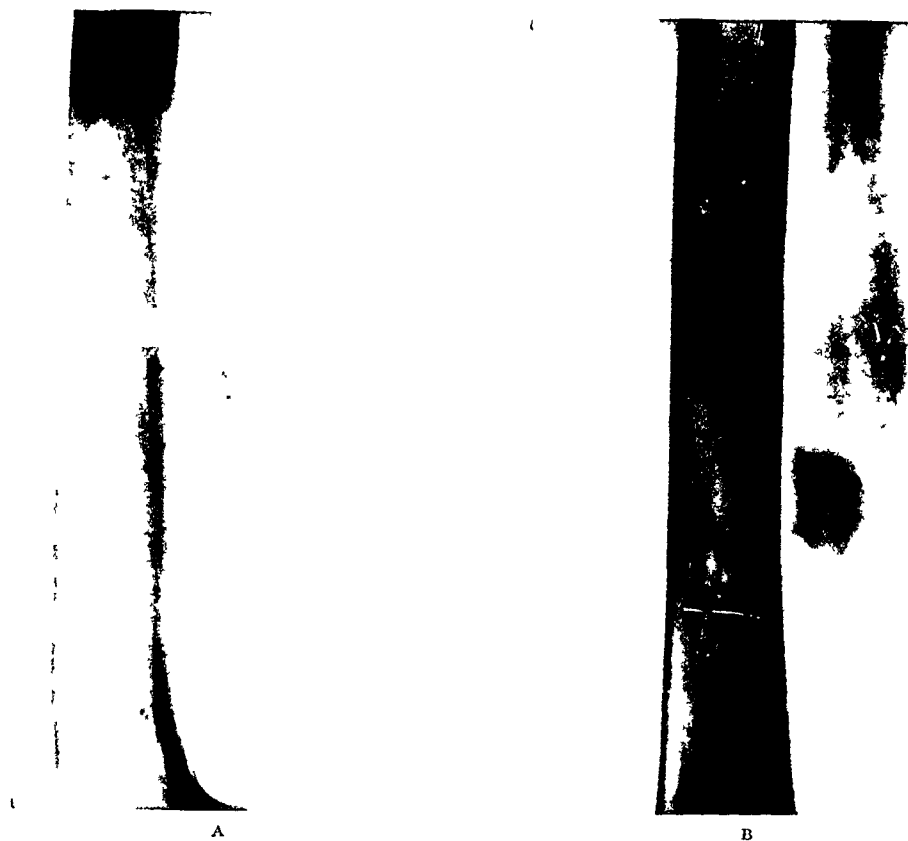


FIG. 3 Tumor of thigh. A, conventional radiograph B, laminagraph.

divisions of the tracheobronchial tree can be delineated through a large part of their extent by the use of properly exposed serial laminagraphs.

Occasionally the vascular tree can be shown equally well. The presence of cavities (Fig. 4) and, to a lesser extent, of tumors, is discoverable. These cannot be found by any other means. There is every reason to believe that the absence of cavitation can be shown with equal facility, but it must be remembered that there is a certain minimum of contrast in density which must be present. For example, if a cavity is completely filled with fluid contents, it would not be demonstrated in an opaque area of the lung. The thinness of the layer radiographed frequently permits, because of the low density differential, the displacement and distortion of very fine

estimated and its third dimension very closely approximated through serial laminagraphs. This fact is invaluable in the surgical therapy of such lesions.

Displacements, distortions and compressions of the tracheobronchial tree are discovered readily. The degree of obliteration of pulmonary cavitation through collapse therapy of any type can be estimated accurately only by this method. Recurrent cavitation in the lung following therapeutic measures can be detected where its presence would be undiscovered by standard methods.

#### OSSEOUS SYSTEM

The osseous system comes next in this field of usefulness, body section radiography being of particular value about the following portions of the axial skeleton: the



FIG. 4. Pulmonary tuberculosis. A, conventional film. B, laminagraph reveals large activity.

skull, particularly its base, the cervical spine, the dorsal spine, sternum and ribs, in the order given. In the remainder of the

radiography they would not be observed. This is equally true of the remainder of the skeleton. In the appendicular skeleton,



FIG. 5. Torticollis. A, conventional film through open mouth. B, laminagraph reveals rotary dislocation of atlas.

axial skeleton, the lumbar spine and sacrum, this method has yet to prove its superiority over conventional radiography.

body section radiography has been of great value in a limited number of instances.

About the base of the skull the greatest

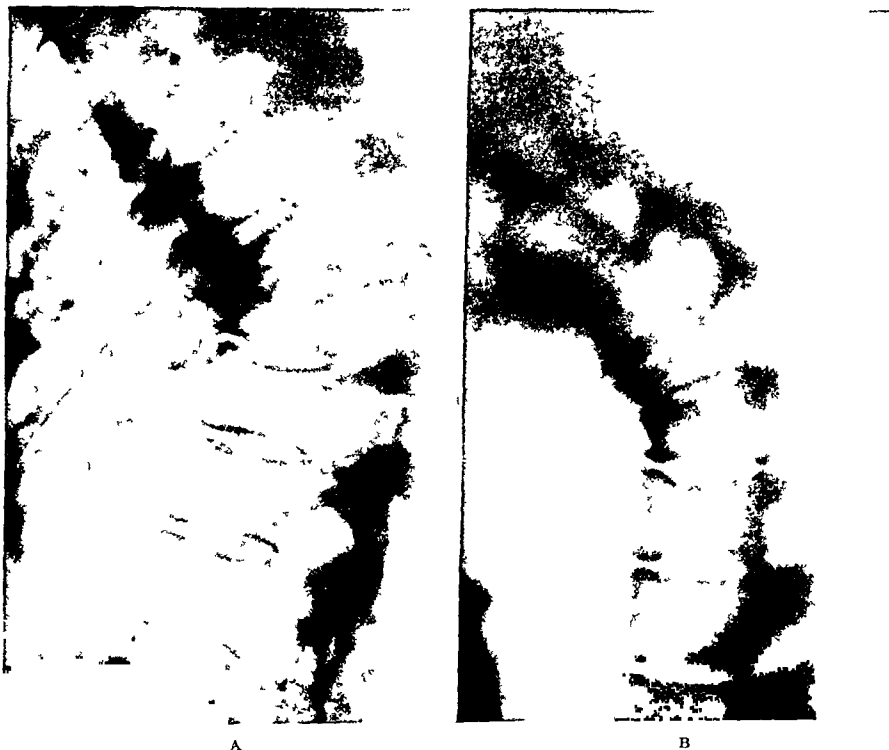


FIG. 6. Old trauma of dorsal vertebrae. A, conventional film. B, laminagraph.

However, shall foci of destruction in bone, either of infectious or neoplastic origin, can be detected readily, although with standard

usefulness has been in examination of the temporal bone, particularly in the case of the mandibular articulation. Pathologic

conditions affecting the internal and external auditory meati the existence of which is unsuspected otherwise, can be discovered. Disease and trauma of the occipito-atlantal junction and at the axis (Fig. 5) have been found with the greatest facility, and correct treatment instituted. Laminagraphic examination of the remaining cervical vertebrae has been of less help.

The upper dorsal vertebrae are visualized clearly in the lateral view through both shoulder girdles. At a lower level they are seen free from the shadows of the overlying ribs and lung markings. (Fig. 6.)

Shadows of structures lying posterior to the sternum can be so blurred that this bone is delineated clearly throughout its extent, but in practice separate films usually are required for the manubrium and gladiolus. The presence or absence of trauma or disease of the sternum can be established readily. This is true also of obscure conditions involving the ribs.

In the appendicular skeleton, small defects in bone have been found, as has been mentioned above, after standard methods have failed. In a patient who was thought to have a primary malignant tumor of the bone, the zone of calcification which led to that belief was shown, through laminagraphic examination, to be entirely independent of the bone. Very small avulsion fractures about the joints have been discovered when their presence was not suspected.

#### NERVOUS SYSTEM AND NEUROVENTRICULOGRAPHY

Except where disease of the nervous system results in bone changes, the laminagraphic examination of the nervous system has not been of value, but the possibilities which lie in the small density differential of the thin layer may be useful in the future. In investigation of intracranial calcifications and in examination of the sella turcica, no superiority over standard methods has been found.

This method has not been employed in either neuroventriculography or encephalo-

graphy. However, its employment in this type of examination has its advocates.

#### DIGESTIVE AND URINARY SYSTEMS

Body section radiography has not been used, except experimentally, in the digestive and urinary systems. However, in both systems there is the possibility of material aid in cases in which the recording of slight contrasts in density would be helpful, or in which elimination of the shadows of unusual objects is desired.

#### VASCULAR SYSTEM

In the vascular system, calcifications in aneurysms have been found and the sac outlined.

There is a possibility that the smallest intracardiac calcifications, since their exact depth in the body is known, can be found, and it is probable that there will be important developments in this field of investigation.

In this connection it may be said that like possibility exists in the other soft tissues. Exact localization of foreign bodies is possible in serial laminagraphs.

#### TECHNIQUE

It is to be repeated that body section radiography is not to be substituted for standard x-ray methods. The latter should precede always, and they are a valuable guide in determining the extent of the area to be examined and the level at which examination should begin.

Only general statements can be made as to the technique. Knowledge as to type and amplitude of movement, and thickness of layer to be radiographed, has to be gained by experience. The general rules of radiography, in regard to the position of the patient, voltage, current, and time of exposure, apply in body section radiography approximately the same as in standard methods. The technique is not difficult, but still requires a considerable amount of trial and error.



## SUMMARY AND CONCLUSIONS

Body section radiography has been defined, and a simple exposition of the fundamental principle of all methods of body section radiography has been made. The several methods of carrying out this procedure have been briefly defined and described. The possible clinical applications of body section radiography in the several anatomical systems have been briefly discussed.

It is concluded that this method of radiographic examination holds great promise for extending the value of radiography.

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PHYSICAL pain is certainly influenced by a *mental factor*, by energy, by freewill. But how do these factors take effect? Do they act only as a brake on the expression, the representation of pain? Or are they able actually to diminish the acuteness of our painful perception?

From—"Surgery of Pain" by René Leriche (Williams & Wilkins).

# INCIDENCE OF HEADACHE, NAUSEA AND VOMITING FOLLOWING SPINAL ANESTHESIA

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SINCE the introduction of spinal anesthesia by Corning<sup>1</sup> in 1885 the literature has contained many reports concerning its advantages and disadvantages. Its usefulness has been definitely established by such pioneers in this field as Bier of Germany, Tuffier of France, Babcock, Pitkin, Stout and others in America, and it is now widely recognized as a valuable addition to the surgeon's armamentarium. The technique of administration has been well standardized, with close adherence to certain basic principles which these men have emphasized. Numerous additions and modifications have been described and various needles and solutions perfected, but analysis has demonstrated that the method of lumbar anesthesia is as safe as its operator. Babcock<sup>2</sup> states, "No solution or technical innovation has displaced the necessity for an accurate technique and rigid supervision. The dangers of spinal anesthesia remain largely with the user rather than the drug or technique employed."

The present analysis is based upon work by two members of our hospital staff, each using the same instruments, solutions and the same technical procedure. The purpose of our study was to determine as accurately as possible the incidence of such post-lumbar anesthetic complications as headache, nausea, and vomiting as found in a series of 500 patients, the majority of whom had been subjected to rectal operations. This selection of cases was made because of the infrequency of these complications, under ordinary conditions, with this type of surgery. Most of the patients in the series analyzed were ambulatory twenty-four to forty-eight postoperative. Since such operative procedures are at-

tended by little shock and by little disturbance to the gastrointestinal tract, it was thought that a more accurate appraisal of the postoperative effect of the anesthesia would be obtained. Most of the studies reported in the literature concerning headache and vomiting following spinal anesthesia have been made on patients subjected to abdominal operations. It is the rule that such patients are recumbent for a period of at least seven to twelve days. This may explain the discrepancy between our figures regarding the frequency of headache and those to be found in the majority of reports. The experience of Harrison<sup>3</sup> with spinal anesthesia among the natives of Arabia, where existing conditions made it necessary that his patients be ambulatory almost immediately following surgery, tends to support this contention. Parker's<sup>4</sup> report indicating a 20 per cent incidence of headache following lumbar puncture alone furnishes additional evidence that the frequency of headaches is much higher where the period of recumbency is short.

Our study was based upon an analysis of 500 cases of lumbar anesthesia in which novocaine crystals were used. In this series 453 patients were given less than 100 mg. of novocaine and forty-seven had 100 mg. or more. The technique described by Labat was observed in at least 90 per cent of the cases. The headaches were classified as moderate or severe. The severe type included all patients who suffered intense pain and those who complained of headache for a period of more than twenty-four hours. In all, 153 patients suffered from postanesthetic headache; of these sixty-seven (13.4 per cent), were considered as severe and eighty-six (17.2 per cent), as

moderate, for a total incidence of 30.6 per cent. In 143 cases (93 per cent), the onset occurred within twenty-four hours after the lumbar puncture; only in ten cases (7 per cent), did the onset occur after twenty-four hours. It was also noted that of the 453 patients who had less than 100 mg. of novocaine, 29.6 per cent had headaches, as compared to 10 per cent of the forty-seven patients who had 100 mg. or more. One patient suffered almost continuous headache for seven days and has complained of frequent headaches for a period of eight months.

When compared with similar figures of other investigators a wide variation was noted. (Table I.) However, this might be

TABLE I  
HEADACHES FOLLOWING LUMBAR ANESTHESIA

	No. of Cases	Incidence of Headaches, Per Cent
Evanston Hospital.....	500	30.6
Pennsylvania Hospital <sup>8</sup> .....	1500	7.3
Babcock (1913) <sup>9</sup> .....	5000	21.0
Koster-Weintrob <sup>10</sup> .....	6000	10.0
Broglio <sup>11</sup> .....	1146	12.5
Campbell <sup>12</sup> .....	410	3.0
Wells <sup>6</sup> .....	557	2.5
Overholt-Muller <sup>7</sup> .....	533	4.0
Stein-Tovell <sup>13</sup> .....	150	6.6

HEADACHES FOLLOWING LUMBAR PUNCTURE ALONE

Parker <sup>4</sup> .....	200	20.0
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expected when it is considered that most series of postanesthetic complications to be found in the literature represent a wide variety of surgical conditions. Inasmuch as the character of the surgical procedure may greatly influence the postoperative course it was our belief that a series of cases subjected to the same, or closely related, operation would provide a more accurate study.

With the possible exception of the one young woman who has complained of frequent headaches and occasional spells of "faintness" for a period of eight months

there have been no serious after effects among any of the patients of our series. A neurological consultant, after examining this patient, assured us that no evidence was present which suggested any relationship between the complaints and the spinal anesthesia, but a history which definitely dates back to the time of operation seems more than coincidental.

It has been our observation that the most satisfactory treatment of a post-anesthetic headache is a prolongation of the "flat in bed" period. Nelson<sup>5</sup> has shown that the cause of the post-lumbar headache was the leakage of spinal fluid from the canal after the puncture and that the incidence of headache can be reduced substantially by plugging the puncture wound with catgut. He also found that the supine position seemed to relieve the headache much more satisfactorily than any other form of treatment. Harrison<sup>3</sup> believes that the injection of irritating solutions

TABLE II  
INCIDENCE OF NAUSEA AND VOMITING FOLLOWING LUMBAR ANESTHESIA

	Nausea and Vomiting, Per Cent	Nausea, Per Cent	Vomiting, Per Cent
Evanston Hospital..	34.6		
Pennsylvania Hospital <sup>8</sup> .....	7.3		
Wells <sup>6</sup> .....	50.0		
Campbell <sup>12</sup> .....	2.0		
Overholt-Muller <sup>7</sup> .....	....	31.0	14.0
Broglio <sup>11</sup> .....	....	18.0	13.0

plus the increased absorption of cerebrospinal fluid at the site of irritation are the factors responsible for most headaches. He found a 5.48 per cent solution of procaine HCl to which  $\text{CaCl}_2$  is added in sufficient quantity to make its strength 0.024 per cent, to be least irritating. He also advocates intravenous administration of 5 per cent dextrose solution in normal saline at the conclusion of the operation, believing that this obviates the danger of

disturbed hydrodynamics of the cerebro-spinal system.

Nausea and vomiting were encountered in our series with greater frequency than that reported by most operators. (Table II.) However, Wells<sup>6</sup> records 50 per cent as the proportion of his patients who suffered nausea and vomiting, while Averholt and Muller found that 31 per cent of their patients had experienced nausea, 14 per cent of them having vomited. Most of our patients received morphine preliminary to subdural anesthesia which may have accounted for some of the nausea, but a lack of control cases renders any conclusions in this regard unreliable. The fact that most of the patients in our series underwent operations on the lower bowel undoubtedly was a factor in the high incidence of nausea.

Twenty-one per cent of the patients studied required catheterization. However, as temporary bladder dysfunction is common following rectal surgery with all types of anesthesia this finding was not considered worthy of comparative analysis.

Despite the frequency of headaches, nausea and vomiting following spinal anesthesia, its wide adoption is testimonial to its usefulness. That it confers certain benefits upon both the patient and the surgeon which can be obtained with almost no other form of anesthesia is admitted by most authorities. We have chosen this method of anesthesia for anorectal surgical patients because of its relatively simple administration and because it provides relaxation of the anal sphincter which is superior to all other forms of safe anesthesia, except caudal-sacral block.

On the other hand, while the disadvantages of lumbar anesthesia for surgical procedures confined to the abdomen and lower extremities are few, certain minor complications are both frequent and distressing, and of these, headaches deserve first consideration. It is our opinion that headaches occur as a complication of spinal anesthesia much more frequently than is commonly realized and that their incidence

is inversely proportional to the time of recumbency. Such a state is deserving of further investigation if we are to continue the use of this anesthetic agent for comparatively minor surgical procedures. We have adopted Harrison's proposal of administering dextrose solution by the intravenous route in an effort to reduce the number of headaches, but as yet our series of patients so treated is too small to deserve comment.

#### SUMMARY

A report of 500 cases of lumbar anesthesia is submitted with special reference to the incidence of postanesthetic headache, nausea, and vomiting in patients who are ambulatory within a short period after surgery.

1. Postanesthetic headache occurred in 30.6 per cent of the cases; this is a much higher incidence than one finds in most published reports and may be explained upon the basis of the following considerations: cases reported in the literature are not selected cases, but those usually requiring seven to ten days of postoperative bed rest; the cases analyzed in the present study were largely those on whom anorectal operations had been performed, these patients requiring only a short period of recumbency.

2. The dosage of spinal anesthesia apparently has no bearing upon the incidence of post-lumbar anesthesia headaches.

3. The onset of the postanesthetic headache usually occurs within twenty-four hours after the lumbar puncture.

4. The most effective treatment of such headaches is prolongation of the period of bed rest.

5. Nausea and vomiting occurred in 34.6 per cent of the patients following lumbar puncture anesthesia.

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It appears that hypophysial deficiency probably is accompanied by increased catabolism of proteins of endogenous origin and imperfect utilization of proteins of exogenous origin, whereas anterior pituitary extract favors protein synthesis.

From—"The Physiology and Pharmacology of the Pituitary Body," vol. II, by H. B. Van Dyke (University of Chicago Press).

# THE SURGICAL PROBLEM IN PERIPHERAL VASCULAR DISEASE\*

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THE surgical treatment of peripheral vascular disease differs radically from the general surgical therapy of similar problems in non-vascular patients and lack of understanding of this differentiation leads frequently to serious and unnecessary complications. With the modern care of the arteriosclerotic and diabetic patients and the improved results in those with thrombo-angiitis obliterans, more of these patients are reaching the age when surgical complications will arise. A report of the surgical experience of the Vascular Clinic at New York Post-Graduate Hospital is therefore timely.

The problem is handled jointly on a combined service with attention directed to the medical and the surgical sides at the same time. The importance of this factor has not been sufficiently stressed. While our purpose is to detail the surgical management of the vascular problems, we wish to emphasize that neglect of the medical or conservative therapeutic measures will result in ultimate failure, no matter how carefully the surgical part is conducted. We feel that only by such synchronized care can satisfactory results be achieved.

## SURGICAL TREATMENT OF INFECTIONS IN VASCULAR DISEASE

1. *Infections.* An abscess, or paronychia, in the vascular patient requires earlier but less radical intervention than in other types of patients, depending, of course, on the extent of arterial disease. Poor vascularity means poor tissue resistance, and while early incision is advantage-

ous, the restricted blood supply will retard healing in any extended opening or exploration.

Anesthesia is a problem in these patients. An agent which anesthetizes by infiltrating the tissue and constricting the already restricted vessels may cause great damage to the tissues. Figure 1 shows the effect of a simple novacaine block at the base of the toe in a patient with previously undiagnosed thrombo-angiitis obliterans surgically treated for an infected ingrown toe-nail. The circulatory status of the foot was not determined prior to operation. The dorsalis pedis artery was occluded and simple palpation probably would have avoided this complication. Adrenalin, frequently added to a local anesthetic, has a more deleterious effect on the tissue by its vasoconstrictor action and must be entirely avoided. Such anesthetics as ethyl chloride, which "freeze" the tissues, are dangerous for the same reason. The importance of feeling for the dorsalis pedis and posterior tibial pulsations prior to contemplated foot surgery is to be emphasized.

2. *Cellulitis.* In the diabetic patient, earlier and more radical intervention is necessary than in the other groups, as the diabetic is non-resistant to slight infection. In the arteriosclerotic and thrombo-angiitis obliterans groups the incision may be much less extensive, as the infection frequently will localize, and even tissue with a necrotic appearance at times will revitalize following the stimulation of collateral circulation by conservative means. Thus early and conservative intervention is the rule, unless the patient has a diabetic complication. Frequent hot soaks

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followed by dry dressings, as will be described, aid materially.

3. *Tenosynovitis*. It is important in

5. *Osteomyelitis*. Osteomyelitis, as shown in Figure 2, in the fifth metatarsal phalangeal area requires sacrifice of the



FIG. 1. Gangrene of the great toe following novocaine infiltration at the base for drainage of infected ingrown nail. (Thrombo-angiitis obliterans)

each infection of this type to x-ray for bone involvement. The usual tenosynovitis in vascular patients is of the slow, necrotizing types which destroys sections of the tendon progressively. Adequate opening of the overlying tissues and the tendon sheath is necessary, but necrotic areas in the tendons should not be excised. Such excision not only destroys portions of the tendon, which may resolve, but an excised tendon will retract, setting up a new site of necrosis some distance up the sheath. The sloughing tendon is permitted to demarcate and during this time serves as an excellent drain. The substitution of some foreign body for such a natural drain is surgically unsound. Increasing the general resistance, with care as to the vascular and metabolic problem, the correction of anemia or other pathologic states, combined with the prevention of any local pocketing in the wound, will facilitate the recovery in these conditions.

4. *Osteitis*. This condition results from the general avascularity and disuse. Unless this cause is recognized, an amputation may be performed on the erroneous x-ray diagnosis of osteomyelitis. Figure 2 shows the type of avascular osteitis frequently seen in these patients. Such bones will regenerate when the overlying infection subsides. Any associated infection with the osteitis necessarily must be drained.

part involved. This will be more carefully considered with amputation.

6. *Gangrene*. Unfortunately, we know of no optimal time to amputate. Observation of regeneration of an apparently lost part makes us conservative. In the diabetic patient, it is not wise to procrastinate too long as an optimal amputation time cannot be maintained for any great period. A study of the blood supply should be made by palpation, oscillometric readings and at times arteriography with a Roentgen opaque solution. Attempts to conserve the extremity below the place shown by these tests to be the point of inadequate circulation only result in multiple amputations, with increased risk. Delay in the arteriosclerotic type is safe for a time if there is no evidence of extension of the infection, above the ankle. Active medical therapy frequently results in surprising recovery. When amputation is performed, it means mid-thigh, except in the very rare instance, since adequate circulation is rarely demonstrable below the knee in these advanced cases.

Patients with thrombo-angiitis obliterans require local amputations late and only after a thorough demarcation has occurred. Conservative therapy is so successful with these patients that we are glad to report that in five years there has only been one major amputation in this disease on the

Vascular Service, with its very active service. Recently we have employed spinal anesthesia which temporarily paralyzes the sympathetics, as a therapeutic measure in threatened gangrene. Embolic gangrene requires high amputation in one-half of those patients surviving the original vessel insult.

Amputations for vascular disease differ from those for traumatic injuries due, of course, to the poor blood supply. Oscillometric readings are of utmost importance in this respect as a guide to the extent of the vessel patency. Figure 3 shows a comparison of the oscillometric readings, the arteriographic tracings, the clinical data, and the pathologic specimen in a patient with embolic gangrene. We were able to demonstrate the fact that the blood supply was inadequate well above the actual arterial block with our oscillometric readings, and we rely more and more on these simple and effective determinations.

The general preparations for amputations include enemas, control of any glycosuria and sedatives, dependent on the age and the condition. In addition to this routine, woollen underwear is used, as most of these individuals stand cold poorly. Cyclopropane, if short and light, has been demonstrated to be the least shocking of the inhalation anesthetics for this type of operation, and hyperventilation for some time postoperatively has materially reduced the incidence of pulmonary complications. The medical management must not be neglected at this stage. The effort to increase collateral circulation as by the use of adrenalin neutralizing tissue extracts, typhoid vaccine intravenously, the oscillating bed and thermostatically controlled heat, should be continued up to the amputation time and resumed thereafter. The problem of the use of prophylactic gas gangrene serum is an individual one, but in the aged, where there has been fecal contamination, it is recommended.

*Local preparations* are important because of the skin contaminations from incon-

tinence and long bed confinement. The skin is cleansed with green soap the day before the operation and twice the operative day.



FIG. 2. Generalized avascular osteitis well demonstrated with an osteomyelitis in the fifth metatarsal phalangeal joint area. Note differentiation of avascular osteitis with its generalized lime absorption and osteomyelitis with bone cortex and continuity lost.

Iodine, if used, must be very weak and removed with alcohol at once to prevent damage to the non-resistant skin. The tourniquet and Esmarch constrictor should be eliminated as this constriction may injure the intima of the proximal vessels. Skin preparations and drapes should be prepared before induction of the anesthesia to shorten the anesthesia time.

#### A NEW TECHNIQUE FOR VASCULAR AMPUTATIONS

The accepted mid-thigh amputation techniques have been found to be unsatis-



factory for vascular work. The damaged arterial supply makes the construction of muscle, fascial and skin flaps impossible

thigh over a board splint applied on the side of the leg, as advocated by Carter, with the painting of the entire area with

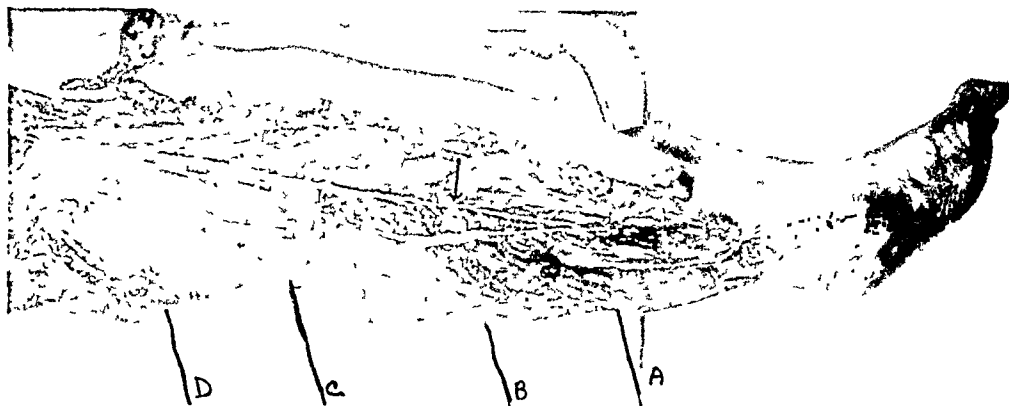


FIG. 3. Embolic gangrene with amputation, showing the value of oscillometric determination in selecting the operative site. A, level of skin gangrene. B, pathologic site of embolus. C, x-ray evidence of collateral circulation. D, oscillometric and operative evidence of circulation competency.

and such experience in our clinic has led us to the development of this amputation procedure. A simple circular incision is made through all structures down to the bone, without efforts to construct flaps of muscle or fascia. Muscles are divided high with as little trauma as possible with the sharp scalpel, and the large vessels are ligated individually with a transfixion suture. The sciatic nerve is divided on tension, ligated, and after cartwheel injection with absolute alcohol to prevent neuromata, is permitted to retract. The tissues are retracted up the femur, and, without stripping the periosteum, the femur is divided with a hand saw and the rough edges smoothed with a wood rasp. All bleeding is carefully controlled. The wound is closed by uniting the skin and subcutaneous fascia only, with interrupted alloy steel wire, size 34 and 36, without drainage.

The dressings are applied after painting with compound tincture of benzoin and carefully sealed with adhesive tape. Skin extension to remove the pressure at the suture line is secured by modified Buck's extension. This is applied with two inch adhesive strips extending from the upper

waterproof shellac. The elimination of the muscle and fascia closure not only simplifies the technique but, by reducing the usual serum collections, makes a better stump for the attachment of the artificial limb. The thick, mushy stumps so frequently seen are the results of the attachment of a muscle shield over the bone end. The steel wire sutures, presented by Babcock, eliminate the tissue reactions to the suture materials and can be left indefinitely should there be any stump infection.

With this simplified technique we have been able to effect primary union in nine out of ten patients. We wish to emphasize:

- (1) Choice of amputation site by oscillometric readings.
- (2) Avoidance of constricting tourniquet.
- (3) Elimination of muscle and skin flaps.
- (4) Modified treatment of the femur, nerve and vessels.
- (5) Closure with interrupted alloy steel wire.
- (6) Sealing of dressing.
- (7) Adhesive tape extension over splint.
- (8) The technical simplicity and speed of the operation.

Should there be questionable vascularity at the operative site, as after emboli, the stump may be left wide open and closed by a secondary plastic repair.

In *local amputations* of toes for arteriosclerosis, a simple disarticulation is used without excision of the tendons, which are left long as drains. In general the toes should be allowed to self-amputate in thrombo-angiitis obliterans cases. Where a clean closure is expected, the racquet type of incision is the best.

*Dressings.* The dressings of vascular patients differ in certain respects from normal surgical methods. More frequent dressings and a more rigid aseptic technique are required. While wet dressings have an important place in the treatment of general surgical infections, vascular patients stand them very poorly, due to the unavoidable cooling and resultant vasoconstriction and reduction of tissue nutrition. This chilling may be sufficient to change a local condition to a progressively general one. Hot soaks followed by immediate change to dry dressings are used entirely in these infections. The soaking solution must be mild in order not to injure the delicate tissues; such solutions as saline, boric acid or azochloramid in triacetin, 1:500 solution, being effective. The maintenance of the normal temperature is important and the light cage equipped with a thermometer with a constant temperature of from 90 to 95 degrees is used. Such simple measures as the care of the frequently associated fungus infections and the avoidance of moisture between the toes all play their part, together with the medical régime, diabetic control and the elimination of tobacco.

#### SYMPATHECTOMY

The published results from sympathectomy in the past are not born out by observations and it is our practice to reserve this more serious surgical procedure for Raynaud's disease and the small group of cases which do not respond to other

measures. Many of the Raynaud cases, selected instances of thrombo-angiitis obliterans, some classified as essential hypertension and the occasional vegetative neuroses seem to respond fairly well. It is important to realize, however, that in a sympathectomy we are merely treating a symptom and not the cause, and while we are eliminating certain conditions pathologic for the patient's present state, we are substituting other, non-physiologic effects for which there must be compensation. We do not deride the good results achieved by ganglionectomy, for the work of White, Adson, Dandy and others have been authoritative, but we do believe that the entire story as concerns sympathectomy results is far from complete or even understood. For the present this type of procedure must still be regarded as experimental in each case.

The posterior approach to the upper thoracic ganglia has proved satisfactory in *upper extremity ganglionectomy*. By excision of a section of the second rib and second transverse process, the lower cervical, first, second and third as well as part of the fourth dorsal ganglia can be resected.

*The lumbar sympathectomy* requires general surgical as well as neural or vascular surgical ability, as all the intra-abdominal complications, at times, may be met. Adhesions, growth, etc., may be encountered and the patient will be as subject to the possibility of peritonitis or obstruction as after any laparotomy. The results in general are better than after cervical ganglionectomy.

The incision should be adequate and midline from the pubis to the umbilicus. The intestines are packed off with pads and by Trendelenburg position. On the *left side* the sigmoid and descending colon must be elevated, the posterior peritoneum incised and the ureter, sigmoid and aorta gently retracted medially. The ganglia lying on the lumbar vertebrae medial to the psoas muscle are dissected free by a gauze sponge. The ganglia of the third and fourth lumbar

segments are removed. On the *right side* the vena cava presents an added problem and the incision in the posterior peritoneum should be made laterally to this organ. The vena cava is then retracted medially and by retracting the cecum, small intestine and ureter laterally, the ganglia can be excised. The usual abdominal closure is made after suturing of the posterior peritoneum.

#### SUMMARY

1. Variations in the treatment of infections in vascular patients from general surgical patients are outlined.
2. General and surgical vascular problems are noted.
3. A new modified technique for mid-thigh amputation is detailed.
4. Sympathectomy is discussed.



THE form of an aneurysm depends first upon whether a considerable stretch of arterial wall gives way or whether one particular spot weakens. A diffuse weakening makes a fusiform aneurysm: a local one, a saccular aneurysm.

From—"Circulatory Diseases of the Extremities" by John Homans (Macmillan).

# SELECTIVE THORACOPLASTY

## RESULTS OF A SERIES OF THIRTY CASES

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IN the surgical management of pulmonary tuberculosis, many advances have been recently made. The reports of thoracic surgeons have improved the outlook to such an extent that we may now safely promise approximately 85 per cent cures. Of all the patients that the phthisiologist sees, only 15 per cent become and remain well after sanatorium regimen alone. In the remaining 70 per cent, collapse therapy must be instituted. Artificial pneumothorax, while not always our first choice, must be accepted as being the most universally applicable. Unfortunately, due to unsurmountable adhesions, one is not always able to induce a collapse by this method. Surgical collapse then becomes necessary for the desired cure.

While the indications for surgery in pulmonary tuberculosis have been somewhat limited in years past, there come to our attention more and more instances where some sort of permanent collapse is advisable. Each thoracic surgeon in the field has his own requisites for operation, but we should like to classify these indications in what seems to us a practical and simple manner:

1. Persistence of symptoms which are distressing to the patient; i.e., severe cough, productive sputum, chills, fever, hemoptysis.

2. Persistence of positive sputum.

3. Persistence of x-ray evidence of cavitation or honeycombing.

As we see more patients with old smouldering lesions, we have been more and more suspicious that honeycombing is the underlying pathology. While it is not always possible to demonstrate this with ordinary films, we feel that one is more apt to have

success with Occhsl's method of taking a hard film with the Potter-Bucky diaphragm. In no instance do we advise surgery for exudative tuberculosis; such a lesion, if not improved with sanatorium care and recumbency, will only glorify mortality statistics. Needless to say, any degree of cavitation must be closed to prevent spread of the disease to other parts of the lung; persistently positive sputum and hemoptysis can frequently be traced to cavitation.

We have no special prerequisites for surgical risk other than our aforementioned maxims. The patient must be as reasonable a risk for thoracic surgery as for any other major surgical procedure. In diabetics, acidosis must be combated; in cardiacs, decompensation corrected; in syphilitics, serology controlled. In fact, anything is done to improve the general operative risk.

Technique, we believe, has been well standardized and needs little comment. Rib beds are routinely formalinized to obviate threatened rib regeneration should a long interval be deemed necessary between stages. No more than three or four ribs are resected at one stage as a rule, the number depending upon the condition of the patient at the operating table. Any evidence of paradoxical respiration terminates the operation. The first rib is removed in toto, and the lengths of succeeding ribs removed is determined by the underlying pathology. In all cases, the resection begins posteriorly with the costovertebral articulation. The last rib or two is resected shorter to afford a better cosmetic appearance to the thoracic cage. In addition, we believe that this helps to prevent impingement of the scapula behind the last resected rib.



FIG. 1. Case 1. A, large basal cavity remaining after temporary phrenic interruption. B, after eleven-rib graded collapse.



FIG. 2. Case 11. A, extensive tuberculosis of right lung and moderate contralateral involvement. B, showing what a phrenic interruption plus one stage of a five-rib collapse will accomplish. Note clearing of opposite lung.

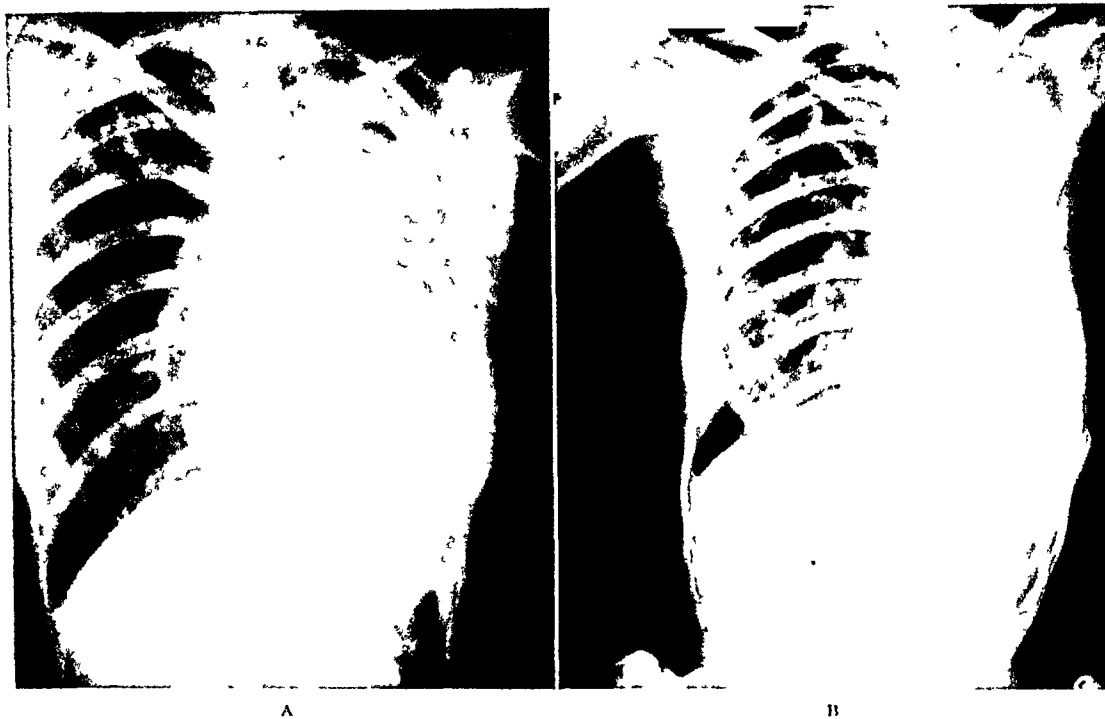


FIG. 3. Case III. A, re-expanded pneumothorax, leaving cavity in upper left lobe. B, after a seven-rib graded collapse.

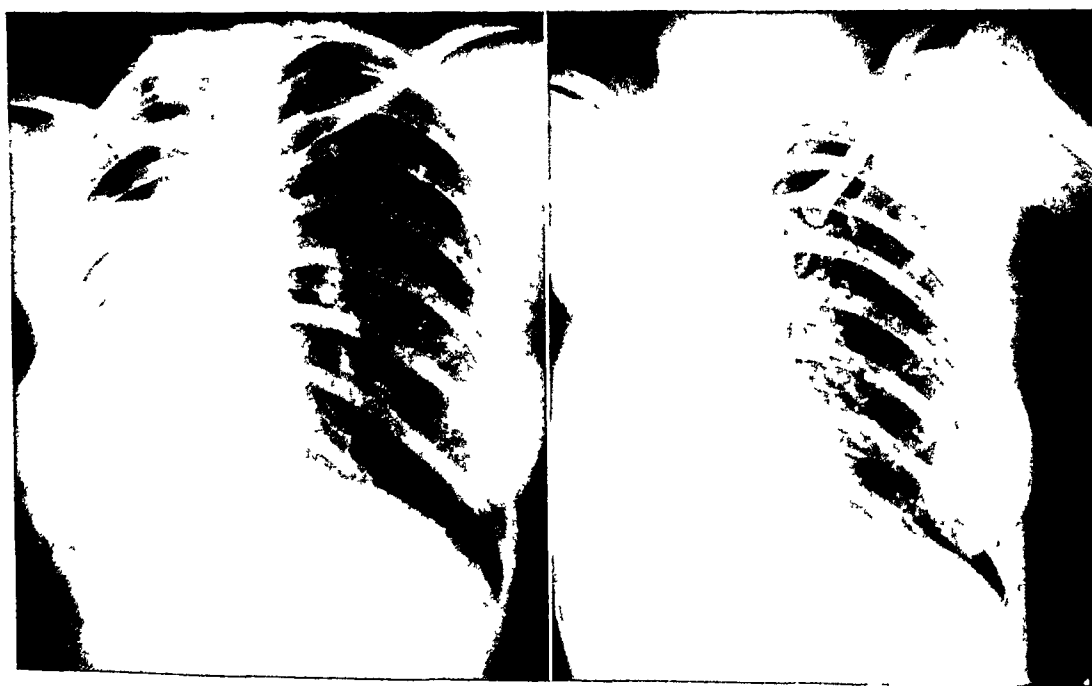


FIG. 4. Case IV. A, 12 cm. cavity in right upper lobe. B, after four stages of a graded eight-rib collapse.

No	Case	Sex	Race	Age	Side	Stages	Stage Interval	No Ribs	Prelim Treatment	Duration of Symptoms	Surgical Indication	Remarks
1	H W F	F	W	61	L	1		4	Pneumo * 3 mo	6 yrs	Pos sputum X-ray—apical cavity	Markedly improved since 2-4-37 Further surgery refused Neg sputum
2	R J	M	W	20	L	2	30 days	5	Phren † 6 wks	3 yrs	Pos sputum X-ray—apical cavity	Well since 5-20-37 Neg sputum and x-rays
3	L M	M	W	60	R	1		3	San'm ‡ 6 yrs	6 yrs	Pos sputum X-ray—extensive involve whole rt with cavity	Incomplete and untraced Did not return
4	C E	M	W	29	L	3	24 days 192 days	9	San'm 6 yrs	7 yrs	Pos sputum X-ray—cavity left upper Hemoptysis-25 x	Improved since 1-18-38 Sputum neg Ant stage necessary for remaining 1½ or daily sputum
5	B J	M	W	28	R	2	30 days	7	San'm yrs 4	4 yrs	Pos sputum X-ray—bilateral involve with cavity rt upper	Improved since 6-15-37 No sputum Opposite lung healing
6	S M	F	W	23	R	2	90 days	6	Rest yr 1½	1½ yr	Pos sputum X-ray—cavity rt upper	Well since 2-18-38 Neg sputum
7	F M	M	W	25	L	2	60 days	7	San'm yrs 3	3 yrs	Pos sputum X-ray—cavity left upper	Improved since 1-10-38 Sputum pos but reduced Needs further collapse
8	Y H	M	W	34	R	2	90 days	7	San'm yrs 5	5 yrs	Pos sputum X-ray—cavity rt upper	Improved since 1-3-38 Dyspnea after second stage Pos sputum—needs further collapse
9	J Y	F	W	34	L	2	30 days	6 scap	San'm yrs 4	4 yrs	Pos sputum X-ray—cavity left upper	Improved since 3-9-38 Sputum decreased
10	E B	M	W	39	R	1		3	San'm yrs 4	4 yrs	Pos sputum X-ray—cavity rt upper	Improved since 3-9-38 X-ray and sputum improvement but both positive Contralateral temporary flare-up Refuses further surgery
11	C G H	M	W	23	R	3	596 days 21 days	7	San'm 3½ yrs Phren 1 yr	3¾ yrs	Pos sputum X-ray—multiple cavities upper rt	Well since 2-27-38 Severe diabetes Prev history septic bilateral parotitis rt TB empyema No surgical complication
12	R J K	M	W	34	R	1		3	San'm mo 2	4 yrs	X-ray—honeycomb lesion rt apex	Well since 12-10-36 Never had sputum
13	E J G	M	W	36	L	1		5	San'm 5½ yrs Phren 3 yrs	6 yrs	Pos sputum X-ray—cavity and honeycomb left apex	Well since 8-6-35 Extensive one stage operation High diaphragm from phrenic op
14	E P	M	W	24	R	1		3	San'm mo 8 Pneum 8 mo	8 mo	Pos sputum, hemoptysis X-ray—cavity rt upper	Improved since 12-4-36 Refused further surgery Working No further hemoptysis Sputum pos
15	C C L	M	W	26	R	4	43 days 665 days 90 days	7	San'm 1½ yrs	4 yrs	Pos sputum, hemoptysis X-ray—7 cm cavity rt apex	Well since 1-31-38 Had refused further surgery after first stage until hemoptysis Anterior stage done

No.	Case	Sex	Race	Age	Side	Stages	Stage Interval	No. Ribs	Prelim. Treatment	Duration of Symptoms	Surgical Indication	Remarks
16	G.H.	M	W	30	L	2	32 days	4	San'm 1 <sup>1</sup> / <sub>2</sub> yrs. Pneum. 16 mo.	2 yrs.	Pos. sputum. X-ray cavity left upper, honeycomb both uppers	Well since 11-30-37. Working. Opposite lung cleared
17	W.T.	M	C	30	L	1	.....	5	San'm 5 yrs. Phren. 3 mo.	6 yrs.	Pos. sputum, hemoptysis. X-ray—cavity and honeycomb upper left	Well since 1-21-36. Streaked sputum for 178 days postoperative. Now asymptomatic and working
18	O.S.	M	C	20	L	2	64 days	5	San'm 8 mo. Phren. 3 mo.	15 mo.	Pos. sputum, chills, fever. X-ray—cavity and honeycomb whole left	Improved since 3-7-36. Refused further collapse. Asymptomatic working
19	J.C.	M	C	30	R	1	.....	3	San'm 5 mo.	13 mo.	Pos. sputum. X-ray—7 cm. cavity rt. upper	Well since 4-16-37. Refused further surgery. Cavity closed; sputum negative
20	E.E.D.	F	W	25	R	3	73 days 50 days	11	San'm 1 yr. Phren. 6 mo.	4 yrs.	Pos. sputum, hemoptysis. X-ray—6 cm. basal cavity rt	Well since 8-8-36. Moderate kyphoscoliosis; no complaint
21	A.K.	M	C	20	L	2	10 days	11	San'm 0 mo. Phren. 2 mo. Thoracotomy 2 mo.	10 mo.	Pos. sputum, chills, fever. X-ray—multiple cavities to 4 cm. with mixed empyema left	Well since 4-16-37. Syphilis 4 plus, controlled by mapharsen. Open thoracostomy necessary for tension pneumothorax. Oleothorax P.O. for empyema pocket
22	E.V.Me.	F	W	23	L	3	21 days 35 days	7	San'm 2 yrs. Pneum. 18 mo.	4 yrs.	Pos. sputum. X-ray—4 cm. cavity left upper	Well since 1-22-36. P.O. pulmonary embolus third stage. Recovery
23	Z.L.P.	F	W	31	L	3	49 days 27 days	7	San'm 10 mo. Pneum. 8 mo.	20 mo.	Pos. sputum. X-ray—cavity left upper. Inefficient pneumothorax	Well since 2-27-38. Closed pneumolysis unsuccessful—2 attempts
24	H.M.H.	F	W	25	R	2	36 days	5	San'm 18 mo.	20 mo.	Pos. sputum. X-ray—honeycomb rt. upper	Well since 5-14-37
25	M.K.G.	F	W	25	L	2	85 days	6 with scap.	San'm 3 yrs. Pneum. 4 yrs.	4 <sup>3</sup> / <sub>4</sub> yrs.	Pos. sputum. X-ray—10 cm. cavity left upper. Honeycomb rt. apex	Improved since 2-17-37. Large cavity closed. Needs bilat. collapse but refuses. Pneumolysis failed
26	M.V.L.	F	W	32	R	2	8 mo.	5	San'm 3 yrs. Phren. 1 yr.	3 <sup>1</sup> / <sub>2</sub> yrs.	Pos. sputum. X-ray—multiple cavities to 4 cm. upper rt.	Well since 3-26-37
27	A.C.L.	F	W	24	R	4	145 days 30 days 30 days	8 with scap.	San'm 5 yrs. Pneum. 2 yrs.	7 yrs.	Pos. sputum. X-ray—12 cm. cavity rt. upper	Well since 3-3-37. First stage ineffective Wilms-Sauerbuch. Anterior stage done. Had P.O. third stage lobar pneumonia. Recovery
28	L.D.	F	W	31	L	2	20 days	11	San'm 10 yrs. Phren.	10 yrs.	Pos. sputum. X-ray—diffuse honeycomb whole left. Hemoptysis	Well since 8-14-35. Extensive 5-rib first stage—graded second stage
29	C.M.M.	F	W	40	R	3	140 days 39 days	5	San'm 11 yrs.	14 yrs.	Pos. sputum. X-ray—honeycomb upper rt. marked fibrosis	Well since 3-30-38. Limited vital capacity (800 c.c.) required
30	E.M.C.	F	W	34	R	2	53 days	5	San'm 16 mo. Phren. 7 mo.	1 <sup>1</sup> / <sub>2</sub> yrs.	Pos. sputum. X-ray—8 cm. cavity rt. upper	Well since 3-1-38

\* Sanatorium regimen.

† Pneumothorax (artificial) previous to surgery. All cases had trials, mostly failures.

‡ Phrenic interruption on the side operated (temporary).



Transverse processes are removed where the cavitation is large or centrally located. Generally speaking, basal cavities are more difficult to close than apical cavities of comparable size. Resection is not so radical in cases where honeycombing was the sole lesion; every effort is made to leave the patient with as much breathing space as possible. On the other hand, some cases require additional anterior collapse.

We have found ethylene-oxygen-local the anesthetic agent of choice. Patients are urged routinely to rid the trachea of secretions before the induction of anesthesia and again before leaving the operating room. To facilitate this, the operation is carried out in slight Trendelenburg position, and the patient placed in bed for four hours in this position. A small dose of nembutal is given the night before surgery and morphine or pantopon immediately before the operation. No atropine is given as it tends to thicken secretions. Operating time is reduced to a minimum without sacrificing careful technique. Patients are given glucose in saline routinely postoperatively and occasionally acacia is added where the pulse volume is weak. In no instance have we had to give transfusion of blood, but we would recommend it where there has been much blood loss. A soft diet is encouraged by the second or third day and the patient allowed a back rest by the fourth day. As a rule, most patients are out of bed by the eighth day. We have always encouraged our patients to be ambulant at least a week before operation. Oxygen is given if cyanosis or dyspnea develops.

While the series of cases we are reporting is not large, we believe it to be significant of nearly every type of surgical tuberculosis encountered. Moreover, unlike sanatorium cases, most of these patients elected surgery as private patients, and not a few were operated on in general hospitals. In the series there were seventeen male and thirteen female patients; twenty-six were white and four colored. All but one were classified as far advanced cases. All had had previous sanatorium management, the

average duration of which was thirty-four months. The average duration of symptoms was 4.2 years; one patient with cavernous tuberculosis had been treated expectantly for fourteen years. The left side was operated on in fourteen patients and the right is sixteen. Eight patients had one stage, fourteen had two, six had three and two had four stages. There was one supplementary anterior thoracoplasty. The average number of ribs removed was 5.7. The average interval between stages was forty-five days; this was computed after discounting instances where the interval was 145, 192, 240, 596 and 665 days in patients who could have been operated sooner but who had to defer surgery because of circumstances beyond their control.

The results of our series were gratifying. There was no mortality; moreover, eighteen patients, or 60 per cent, were cured, ten, or 33 per cent, were improved, and two were unfinished at the time of this report. Of the improved classification we believe that the majority could be made eligible for cure if they elected further surgical collapse. Sooner or later recurrence of symptoms is bound to occur, and we strongly urged such patients to continue treatment with this in mind. One patient had severe diabetes with blood sugar levels before operation as high as 420 mg. per 100 c.c. However, no complications occurred in this case, and the patient subsequently underwent a bilateral cataract operation with like success. It was interesting to note that the insulin requirement in this case was reduced from 150 units daily before operation (when the patient was bed-ridden) to 35 units postoperatively, and this in spite of a gain in weight, increase in diet and a marked increase in energy output. All patients had sufficient vital capacity except one whose measure was 800 c.c. In this case as in another incomplete case, operation was carried out by single rib removals to insure recovery.

There were various sized cavities in this series, the largest being 10 by 12 cm. We have tried to emphasize that any lesion

comprising 25 per cent pulmonary tissue in one lung must have permanent collapse, and it is our feeling that much of the honeycombing that we see is due to re-expansion of inadequately collapsed cases of artificial pneumothorax. Hemoptysis was a common complaint in such cavity cases and it frequently persisted for some time after operation. One patient had had twenty-five severe hemorrhages before coming to surgery. Another was subjected to the old Wilms-Sauerbruch operation for a relatively large cavity; this took three stages of secondary thoracoplasty for eventual closure. Our aim was cavity closure in each instance so that the walls of the cavity would be held closed permanently after fibrosis was established.

There was but one case of postoperative flare-up with recovery. Any sign of exudative inflammation as evidenced by interval x-rays was sufficient to postpone further surgery. There was one postoperative pulmonary embolus with recovery. One patient had a postoperative wound infection which we believe came from a crust at the site of a previous scar. In this regard, we emphasize rigid asepsis both before and at operation. Green soap and water, repeated, then ether and mercresin constituted our routine.

#### CONCLUSIONS

We have not presented anything new in the surgical management of pulmonary tuberculosis. However, we wish to re-emphasize certain conclusions which we believe must be accepted if good results are to be obtained.

1. The type of operation has been well standardized and is relatively safe; there

were no deaths in this series of consecutive cases representing sixty-two stages of operation.

2. There are certain requisites for surgical collapse as well as for surgical risk. Contralateral disease is no contraindication; as a matter of fact, the unoperated side seemed to improve with each stage of operation where involvement had been the result of cross infection from the involved side.

3. Minimal sacrifice of pulmonary tissue but sufficient collapse for cavity or honeycomb closure is paramount.

4. The results of this series of cases are encouraging. Although only 60 per cent of our patients are well,\* the 33 per cent who were improved are eligible for the "well" category if they can be persuaded to elect further surgical collapse. There were no unimproved patients in the series.

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\* The term "cure" has been used synonymously with "well." This does not conform to the symbol as used by the National Tuberculosis Association.



# EMPHYEMA THORACIS

## EXPERIENCES IN THE TREATMENT OF 104 CASES EMPLOYING A DOUBLE-CHANNEL CATHETER FOR DRAINAGE

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THE diagnosis of empyema thoracis having been made, it is accepted by many authors that the selection of a method or combination of methods to be used in treatment must be governed by the individual, clinical features and requirements of the case. The division of the profession into two camps, one advocating the so-called "open method" and the other the so-called "closed method," is unfortunate.

Surgically speaking, empyemas have been divided into two groups, the synpneumonic and the postpneumonic types. These conditions, although both bear the label "empyema," are different in every respect. No method of treatment can be intelligently selected without a thorough appreciation of these differences and their significance. The following points of contrast will make clear the most important differences between them:

### Synpneumonic Type

1. Pus accumulates early in the pneumonia, sometimes even before the consolidation is apparent.
2. Cultures yield the streptococcus, or, less frequently, the colon bacillus, alone or as the predominating organism in a mixed pyogenic infection.
3. Onset is not associated with a change of temperature but the pneumonic fever continues as a sustained rise.
4. Toxicity is marked.
5. Pus is thin with few fibrin clots.
6. There is rapid involvement of the general pleural cavity, adhesions forming late.

### Postpneumonic Type

1. Pus accumulates late in the pneumonia, or even after the pneumonia has resolved.
2. Cultures yield the pneumococcus alone or as the predominating organism in a mixed pyogenic infection.
3. Onset is marked by a resumption of fever, which assumes septic characteristics.
4. Toxicity is slight.
5. Pus gradually becomes thick with much coagulated fibrin.
6. There is a tendency to localization, with early formation of adhesions.

There is no reason to doubt the sincerity or honesty of any of the authors who have reported their individual methods of treatment of this disease. It must, therefore, be deduced that success depends more upon the individual than upon the method which he uses.

The method of choice in drainage depends upon the underlying pathologic physiology which requires correction. Of paramount importance are the following:

1. The subatmospheric pressure normally within the pleural cavity.
2. The infecting organism.
3. The presence or absence of localizing adhesions.
4. The site at which pus most directly contacts the chest wall.
5. The amount of fibrin clots present.
6. The patient's general clinical condition.
7. The presence or absence of bacteremia.

Other things being equal, a lung upon the autopsy table responds to the same physical laws as a lung within the pleural cavity. In other words, a consolidated lung will sink and an aerated lung will float. Except, therefore, in massive empyemas, involving the whole pleural cavity, or those which form in the presence of important preëxisting adhesions, the re-aerated lung in postpneumonic empyema will float and the greater amount of pus will be found in the posterior costal gutter. The consolidated lung in synpneumonic empyemas, on the other hand, will sink and the pus will be displaced upward to the anterior chest wall. Exception, perhaps, should be made for those cases of streptococcus empyema, which occur in the absence of any demonstrable consolidation. It

becomes immediately apparent that the physical and x-ray signs must be interpreted in the light of this simple fact. The distribution of the pus may also differ according to the position occupied by the patient in bed during the sojourn of the pneumonic consolidation. In one of the author's cases, bilateral empyema developed while the patient was in a respirator. The longitudinal distribution of the pus in the pleural cavity was so uniform that the x-ray failed to give diagnostic evidence of its presence.

It is also apparent that the routine choice of the eighth interspace in the mid-scapular line as the site of election for diagnostic puncture or for drainage cannot be expected to yield the best results.

In the average case, the diagnosis of empyema is easy, as is also the localization of pus by diagnostic tap. It is clear, however, from the remarks of the preceding paragraph, that mistakes can readily be made. If the pus is loculated, it may be apically placed, supradiaphragmatic or interlobar; or there may be several pockets either isolated or communicating. In such instances, the same care must be taken in localization as would be given a lung abscess.

In general, it may be said that, if any difficulty is encountered in obtaining pus at thoracentesis, or in demonstrating an ample amount of free space with the aspirating needle, x-ray localization is necessary. This can generally be accomplished by taking, in addition to the usual postero-anterior film, an anterior and posterior oblique view of the affected side, especially after the replacement of some pus by air. It goes without saying, of course, that, in multilocular accumulations, the greatest care must be taken and drainage effected at more than one point if necessary.

In patients who remain immobile over long periods of time in bed, the cellular elements in the pus settle to the bottom of the pleural cavity. It is then possible to obtain by aspiration an entirely erroneous

idea of the percentage of pus in the effusion, depending upon whether the heavy sediment or the relatively clear supernatant liquid is drawn out.

The cure of an empyema takes place by the obliteration of the pleural cavity through synechia of the opposing surfaces. No empyema can be looked upon as cured until synechia is complete, and the faster this fusion can be induced, the more quickly is a cure obtained.

In open drainage the process of healing is a progressive adhesion of the two surfaces, beginning at the periphery of the empyema pocket and moving inward. Clean exudative pleural surfaces, when brought into contact with each other, will fuse. It is apparent, therefore, that fusion will take place only when there is no pyogenic membrane and when the production of exudate has ceased, i.e. when the underlying inflammatory process has subsided. It is logical to assume that when these conditions exist, the progress of healing is accelerated by approximating the surfaces of the pleura. The application of negative pressure to the pleural cavity not only provides mechanically for this approximation, but in so doing causes the removal of the pyogenic membrane by friction of the two surfaces. In acute cases, the author has seen this process completed in the remarkably short time of ten days.

The choice of time and method in drainage is much facilitated by this knowledge. Unless dyspnea, toxicity, or remote complications, such as pyelitis or nephritis, demand early interference, nothing is to be gained by drainage before the pneumonic process is cleared up. The patient suffers less inconvenience if he is relieved symptomatically until such time has arrived by repeated aspiration. It is not always easy to judge the condition of the underlying lung, and, in case of doubt, early drainage under strictly closed precautions is better than allowing the defensive thickening of the pleura to proceed too far, inviting the complication of bronchial fistula or chest wall abscess.

Below is presented a method of drainage, which I have used with considerable success. I have no desire to urge its general adoption. On the contrary, I believe that when the fundamental principles are observed, an individualized technique is more likely to assure the attention to detail which is so essential to success. There is a persistent opinion among a certain group of men, however, that treatment cannot be begun until a rib has been resected. This attitude is dangerous and reactionary. Even its advocates admit its disadvantages in children, where the problems faced are the same as in adults, but where the risks of anesthesia, open pneumothorax and mediastinal flutter are naturally increased. Rib resection still has its place in the treatment of empyema but, where proper nursing and supervisory care are available, complete drainage under all circumstances in the acute cases is possible without its use. If the operator proceeds without prejudice upon the assumption that empyema per se should never be a cause of death, it is generally easy to decide upon the right thing to do at the right time.

It is unnecessary to enter into the general physiologic and anatomic principles governing the treatment of empyema, since the subject has been treated comprehensively in a vast literature already extant. Studies made by Graham,<sup>1</sup> Connors,<sup>2</sup> Fitzgerald,<sup>3</sup> Kenyon,<sup>4</sup> Holt,<sup>5</sup> Harloe,<sup>6</sup> are especially recommended for the perusal of the reader who wishes to go more deeply into the general aspects of the subject.

#### TREATMENT OF CHRONIC EMPYEMA

By chronic empyema is meant, in this group of cases, patients who have been draining pus externally or internally from the pleural cavity for two months or more without showing signs of improvement.

The causes of chronic suppuration in empyema are: (1) foreign body in the pleural cavity; (2) osteomyelitis of the ribs; (3) specific infections; (4) bronchopleural fistula; (5) inadequate drainage;

and (6) pleural dead space. This paper concerns itself chiefly with the application of negative pressure to the treatment of empyema. It is obvious, therefore, that a discussion of the above enumerated problems goes beyond its intended scope. They shall be considered only as they are related to the author's method of treatment.

1. *Foreign body in the pleural cavity* should always be ruled out before the treatment of chronic empyema is begun. When present, it can be removed by pleuroscopy without operation and without anesthesia, local or general. Irrigations under negative pressure with the catheter inserted through the sinus hastens recovery.

2. *Osteomyelitis of the ribs* was the only associated condition requiring rib resection in the seventeen cases of chronic empyema reported herewith. In two cases, it was the only condition present, the empyema having been satisfactorily treated in one case fifteen years previously.

3. Of *specific infections*, the commonest offender is the tubercle bacillus. Negative pressure irrigations can be successfully used to keep the pleura clean, to bring about expansion of the lung and to prevent amyloidosis. The underlying tuberculous pulmonary lesion can be treated by staged thoracoplasty at the same time. Experience to date would indicate that synechia of the pleural surfaces is not likely to take place. Some reduction, however, in the volume of pleural dead space may be obtained, and the radical nature of the Schede operation as at present used may be limited in direct proportion to the success of efforts in this direction.

4. *Bronchopleural fistula* is a much more frequent complication of empyema than is commonly believed. In a series of twenty-five consecutive cases, the writer injected methylene blue into the pleural cavity at the time of the initial thoracentesis. It was expectorated in ten cases (40 per cent). This is undoubtedly a higher average than would be found in a larger series of patients, but it emphasizes the fact, never-

theless, that bronchopleural fistula should always be kept in mind as a possibility. In its presence, negative pressure cannot

lung as it gradually occupies the posterior costal gutter.

5. *Inadequate drainage as a cause of*

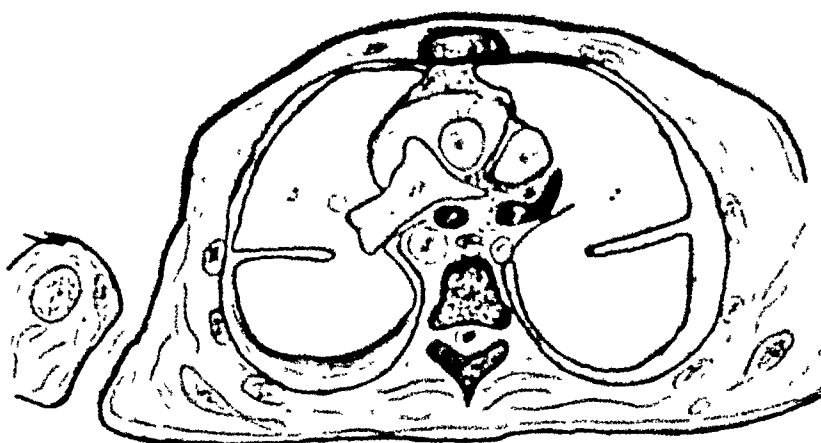


FIG. 1. Cross section of human thorax just below the bifurcation. The close relation of the pleural cavity to the posterior bronchial wall is clearly shown, especially on the right. The relation is equally close on the left, but slightly lower. The bronchi are indicated at ".

be used and irrigations must be used with great caution, if at all, on account of the danger of flooding the lung. It should not be looked upon as a serious problem in patients not previously operated on. In this series, spontaneous closure took place in all cases in from five to seven days following the initiation of drainage.

If a cross section of the human body is made at the level of the bifurcation, the parietal pleura is found to be in close relation to the posterior wall of the stem bronchus on both sides. (Fig. 1.) The bronchi are deficient in cartilage posteriorly and have no external protection except a thin layer of loose areolar tissue. They are, therefore, directly subjected to the effects of pus confined within the pleural cavity under increased pressure. Here, then, is the easiest and most direct route for perforation into the airways. I have been able to establish this as the site of fistulization in four cases; two by bronchoscopy, one at autopsy and one by lipiodol radiography. (Fig. 2.) The anatomic location explains the frequency and rapidity with which these openings close, since, as soon as drainage is established, they are occluded by the re-expanding

chronic empyema results from: (a) dependence upon an opening which is too small to evacuate the pleural cavity; (b) allowing the external fistula to close before the lung is fully re-expanded; or (c) improperly

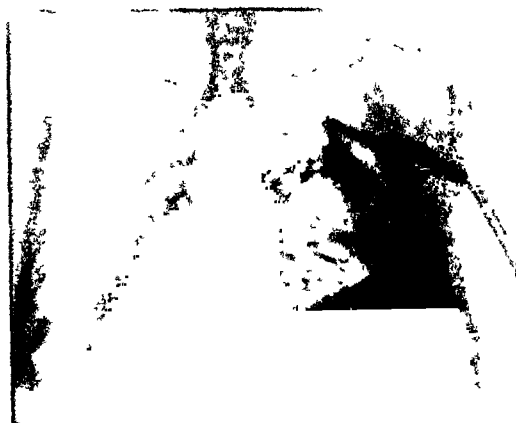


FIG. 2. X-ray of chest after injection of posterior sinus by opaque oil. The location of the fistula in the right bronchus is clearly indicated. (See Figure 1.)

selected drainage site. The first two are faults frequently encountered in closed drainage cases. They may be corrected by rib resection if this method is used early enough to prevent extreme thickening of the pleura. A cure can be obtained more quickly, however, and without rib

resection, by the method to be described later. In the third instance—improperly selected drainage site—the fault lies in improper localization of the pus. The tube may be inserted too high, leaving a collection of stagnant pus below it. It may be too near the periphery of a localized pus pocket. The opening will then be quickly obstructed by the rising diaphragm or the re-expanding lung.

6. In the treatment of chronic empyema with *pleural "dead space"* as the only apparent cause of chronicity, the application of the method to be described finds its greatest value.

It has been claimed by some authors that, when the lung fails to re-expand, an atelectasis, due to bronchial obstruction, should be suspected. I have not been able to find in my personal experience or in bronchoscopic examinations in the services of other men, any clinical evidence in support of this theory. On the contrary, even if obstruction of the bronchus were found, it would have to be looked upon as the effect, rather than the cause, of the thickened pleura and the collapsed lung.

The removal of the obstruction should, therefore, be sought as a natural result of the restoration of function by re-expansion of the lung. In seventeen chronic cases (see summary Table II) the empyema was cured without rib resection; in eleven cases this was accomplished by causing a partially atelectatic lung to re-expand. The single or combined effect of removal of foreign body from the pleural cavity; the correction of the drainage site, and the application of negative pressure, either through the old, or through the corrected site of drainage brought about the result. In seven of these cases, I am convinced, a cure without operation must be attributed to the beneficial effect of negative pressure on a clean and gradually thinning pleura. At least, it has been demonstrated beyond doubt that, in the absence of osteomyelitis of the ribs and specific infections of the pleura, no major surgical procedure should be embarked upon without giving the

method a fair trial. It has never failed in my cases except in the presence of the two conditions mentioned above.

#### METHOD OF DRAINAGE

This method was first described in 1933. Up to that time, no record could be found in the literature of the use of a two-way catheter in the treatment of empyema. Recently, however, Bloxsom<sup>7</sup> has described a set-up utilizing a return-flow glass douche bulb by which the same principles of treatment may be applied.

In the author's method,<sup>8</sup> a flat catheter, 13 mm. wide, with two size 18 French channels, is inserted intercostally by a specially-designed trocar and cannula. (Fig. 3.) If there is no bronchial fistula, the branches are connected to a bottle containing normal saline solution on one side of a supporting standard and to a syphon system on the other side. (Fig. 4.)

It will immediately be seen that variations in the application of pressure to the pleural cavity may be regulated by changing the levels of the saline bottle or of the drainage bucket. In practice, however, it has been found best to initiate drainage with the relative levels as shown. Inflow and outflow may be regulated by pressure of the fingers on the corresponding tubes. The content of the pleural cavity is alternately increased and decreased, using hot salt solution. In this way, the collapsed lung is gently "massaged" until evacuation of the pus is complete, a period which need not occupy more than thirty minutes. Continuous irrigation under constant negative pressure is then started. In order to avoid too great an exertion of negative pressure in the pleural cavity, the drainage bucket is gradually raised. The best operating position has been found to be where the water level in the drainage bucket is from 12 to 16 inches below the water level in the syphon bottle when this level is in the same horizontal plane as the intercostal tube.

In the presence of bronchial fistula, it is evident that neither negative pressure

nor the free use of irrigating solutions can be used. The apparatus is then set up as shown in Figure 5. Bronchial fistula in

of the water forming the seal. It is, therefore, necessary, to avoid loops, kinks and pendants in the outflow tube. The inflow

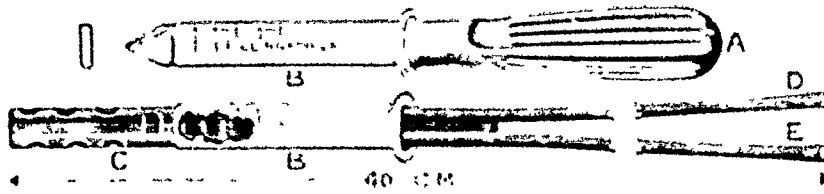


FIG. 3. Special trocar, cannula and two-way catheter. (Modified from the original of Dr. Norman Bethune.)

the ordinary post-pneumonic empyema, in the opinion of the writer, closes more quickly if the development of an intrapleural positive pressure is prevented. This is accomplished by attaching the

tube may be used with a Murphy drip, with intermittent irrigation of suitable quantity, or without irrigation, as the case requires. Most fistulas will close in from five to seven days. The arrangement

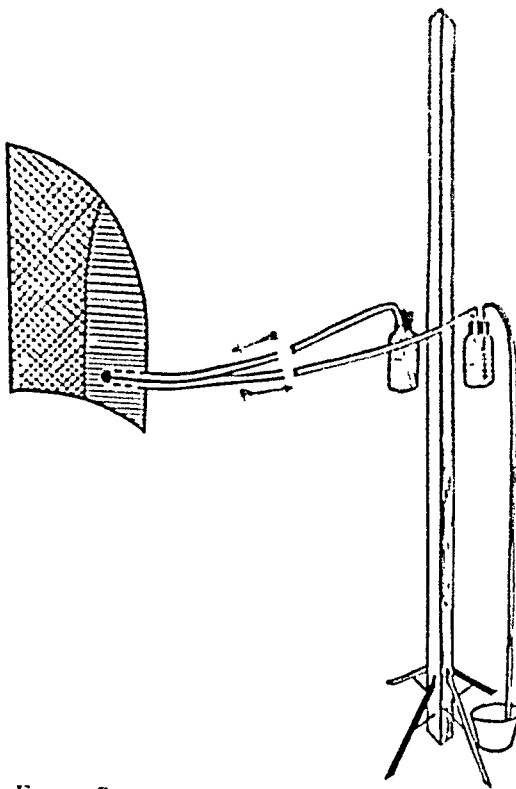


FIG. 4. System for the initiation of drainage in the absence of bronchial fistula.

outflow side of the catheter to the ordinary "water seal." It must be noted, however, that this device is not effective unless there is (a) direct and continuous downhill flow from the chest wall to the drainage bottle and (b) constant maintenance of the outlet of the drainage tube at a level not more than 1 cm. below the surface

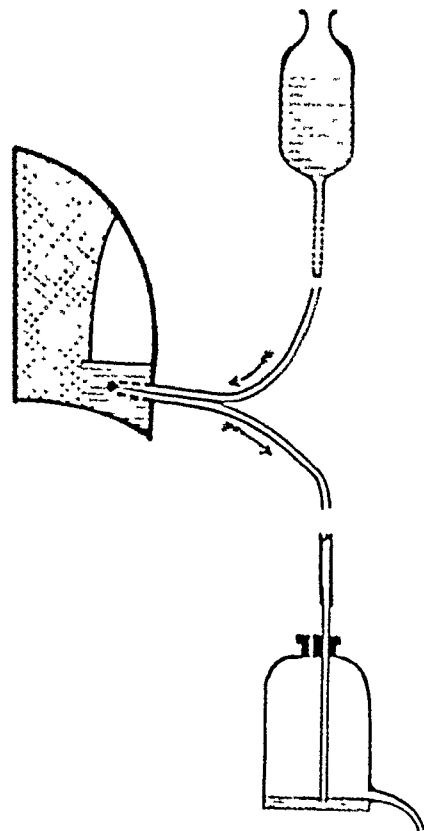


FIG. 5. Drainage system in bronchial fistula. (See text.)

of bottles is then changed to permit of negative pressure irrigations as in Figure 4.

The maintenance of an airtight contact is provided by the use of a rubber sponge dressing. An ordinary bathroom sponge of fine texture, not less than 1 inch in thickness, is sterilized. After the insertion



of the catheter, the sponge is perforated by a pointed clamp without tearing. The catheter is seized and drawn through. The sponge is applied directly to the chest wall and strapped down by adhesive tape.

The presence of large masses of coagulated fibrin, found especially in pneumococcic empyemas will interfere with drainage. This difficulty, however, is easily overcome. If coagulum is known to be present in the pleural cavity, it may be evacuated when drainage is established, in many instances. The caliber of the author's special cannula is large enough to permit its escape, except where particularly large quantities are present, or where it is considered unwise to empty the pleural cavity quickly. In such instances, the catheter is inserted and the pus removed in the manner described below.

During the first three to four days, drainage is maintained by alternating the direction of flow in the branches of the catheter. This allows time for the coagulum to detach itself from the pleural surfaces. The catheter is then removed; the patient is tilted to the affected side and asked to cough. As the clots are forced out of the sinus, they are seized by forceps or a hemostat and withdrawn. In this way, I have removed as much as a pint of coagulum in large masses, without technical difficulty and without embarrassment to the patient. Following this, the catheter is reinserted and irrigations may be continued without interruption.

At the end of the first two days of drainage, the return from the pleural cavity is clear. Since the pleural cavity is empty, toxic absorption does not take place. The inflammatory membrane covering the pleural surfaces is dissected free by the action of the digestive ferments of the underlying white blood cells. With the lung maintained in a state of re-expansion by an appropriate degree of negative pressure, friction of the pleural surfaces rapidly removes this membrane. It can be seen to pass out of the drainage tube in the form of whitish flocculent masses.

Actual pathologic section of a twenty-four hour accumulation of this material shows that it consists of partially digested, fibrous and granulation tissue, with entangled, amorphous debris. This action is particularly important in the case of chronic empyemas where a thickened and inelastic pleura may be the sole barrier to the obliteration of pleural dead space.

As soon as this sloughing-off process is complete, two clean exudative surfaces find themselves in intimate contact and fusion rapidly takes place. The tube is removed when the volume of the pleural pocket is not more than 25 to 35 c.c. A section of rubber dam is inserted to maintain patency of the sinus until the space is completely obliterated. The closure of

TABLE I  
ETIOLOGY IN 104 CASES

	No. of Cases	No. of Deaths	Per Cent Mortality
I. Not post-pneumonic: Complications of			
Thoracic operations....	3	1	
Abdominal operations..	5	1	
Subdiaphragmic abscess	1	1	
Trauma to chest.....	1	1	
Total.....	10	4	40
II. Post-pneumonic:			
Acute			
Under 5 years.....	13	1	7.7
Over 5 years			
Unilateral.....	60	4	6.25
Bilateral.....	4	0	
Chronic.....	17	0	
Total.....	94	5	5.31

TABLE II  
CHRONIC EMPYEMA  
Cause of Chronicity

Foreign body in pleural cavity.....	2
Osteomyelitis of ribs.....	4
Inadequate drainage.....	6
Incomplete expansion of lung (pleural thickening).....	5

Total..... 17

No case with tuberculous, or other specific infecting agent is included.

this residual space often requires as long, or even longer, than the adhesion of the entire pleural surfaces when they are kept constantly clean and continuously applied to each other.

#### SUMMARY OF CASES

Elapsed time since the initial drainage, in these cases varied from three months to six years, the average duration being one year, approximately. In the case of six years' duration, the patient still has a residual sinus from infected bone but has been able to resume his normal activities.

#### COMMENTS

Of the acute cases treated by drainage, eighteen were in patients over five years of age, unilateral and uncomplicated. These cases were cured in an average of 14.6 days.

One patient was cured by two aspirations of an empyema yielding a pure culture of *Staphylococcus aureus*.

In one case of bilateral empyema yielding a pure culture of hemolytic streptococcus, the right side was drained. The left side cleared up after a single aspiration.

Three patients, in whom a late diagnosis was made, recovered after rupture into the trachea, without further drainage.

Causes of death in the five cases reported in post-pneumonic empyemas were as follows: (1) intractable diarrhea in a 7 months old infant (the empyema wound was closed two weeks before death); (2) embolus to the brain (?); (3) hemolytic streptococcus septicemia; (4) pneumonia in the contralateral lung (two cases).

Sulfanilamide and sulfapyridine were used by various physicians in adequate dosage, in sixteen cases, with the following results:

1. Drugs administered after the diagnosis of empyema and after the apparent resolution of the pneumonia—six cases—no effect.

2. Drug administered during the pneumonia and before the diagnosis of empy-

ema: three patients had sterile effusion (exudate) at first aspiration; one patient became sterile one week after first aspiration, at which time a pure culture of anaerobic streptococcus had been obtained; three patients became sterile after two weeks drainage and needed no further treatment; three patients had clinically and x-ray diagnosed effusion which disappeared spontaneously.

It would appear therefore that when these drugs (especially sulfapyridine) are administered in pneumonia, the complicating effusion, if any, is likely (1) to be sterile throughout, or (2) to become sterile under treatment more rapidly than would be the case in the absence of the drug.

#### SUMMARY AND CONCLUSIONS

1. A method of treating empyema is described, which permits of the regulated application of negative pressure to, and constant irrigation of, the pleural cavity.

2. The apparatus is extremely simple and easy to operate. Rib resection is unnecessary, even in the presence of large amounts of coagulum, but adequate nursing and supervisory care are essential.

3. Ninety-four cases of post-pneumonic empyema are reported with a death-rate of 5.31 per cent. No deaths were due to the empyema.

4. Uncomplicated post-pneumonic empyemas should be cured in from two to three weeks.

5. Observations are made from the author's experience in connection with the physiology and anatomy of open and closed pneumothorax and bronchopleural fistula.

6. Evidence is presented in support of the author's belief that the obliteration of the pleural cavity is accelerated by the use of negative pressure and the maintenance of two clean granulating surfaces in apposition.

7. The results of the application of the same principles in the treatment of chronic empyema are shown. Seventeen cases were

treated, with no deaths and without rib resection except for osteomyelitis.

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VENOUS thromboses may be associated with, if not actually a reflex cause of, arterial spasm serious enough in some cases to induce gangrene of the limb.

From—"Circulatory Diseases of the Extremities" by John Homans (Macmillan).

# THE TREATMENT OF VENEREAL LYMPHOGRANULOMA WITH SULFANILAMIDE\*†

## A PRELIMINARY REPORT

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THE purpose of this communication is to present evidence to show the effectiveness of sulfanilamide in the treatment of the anorectal and inguinal manifestations of venereal lymphogranuloma. The value of sulfanilamide in this disease has been reported by others.<sup>1,2,3,4,5</sup> Shropshear<sup>3</sup> and Knight and David<sup>5</sup> have stressed the value of this drug in the treatment of the anorectal phase of venereal lymphogranuloma, with which we are particularly concerned. However, it should be noted that a precise plan of treatment with sulfanilamide has yet to be evolved.

It is likely that sulfanilamide exerts a specific effect on the virus of venereal lymphogranuloma, and, at least in part, on the secondary contaminants. Our experience supports these possibilities. Whether the beneficial effect of sulfanilamide is temporary or permanent has not yet been established. Observations over a period of time will determine this point.

Our studies appear to show that large amounts of sulfanilamide should be given during the initial period of treatment. We have found that a minimum of 24 Gm. of sulfanilamide should be administered over a period of four days. This can best be accomplished in a hospital, as it is well known that ambulatory patients cannot take large amounts of the drug with safety. Furthermore, it is dangerous to entrust potent drugs to these patients without proper daily medical supervision. Early toxic symptoms may go unrecognized, as they are unpredictable.

After the initial period of treatment in the hospital, our patients were given

approximately 3 Gm. of sulfanilamide daily for about three months, preferably without a rest period. We are not yet satisfied that this is sufficient treatment. Another point about which we are in doubt is whether the rectal route of administration of sulfanilamide is superior to the oral in these cases. Our experience with the first case herein reported suggests the former possibility.

During the period of treatment in the hospital, daily determinations of the concentration of sulfanilamide in the blood were made. Sole reliance should not be placed on the amounts of the drug administered because the factors of absorption and excretion vary in each patient. It appears that a concentration of 5 or more mg. of free sulfanilamide per 100 c.c. of blood is essential. In three ambulatory clinic patients, the results obtained with sulfanilamide were poorer than in the patients treated in the hospital. In one of the ambulatory patients, little or no change in the status of the rectal stricture was noted after the daily administration of approximately 3.5 Gm. of sulfanilamide until 50 Gm. were supposed to have been taken. At the end of that time the concentration of sulfanilamide in the blood was 1 mg. free sulfanilamide per 100 c.c. It is difficult to determine how accurately dispensary patients followed our instructions as to dosage, limitation of fluid, etc. This furthers our conviction that these patients do better when treated in a hospital under strict control and supervision.

Sulfanilamide exerted the most pronounced effect on the inflammatory and

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† Sulfanilamide was furnished by the Medical Research Department, Winthrop Chemical Company.

suppurative processes. The scar tissues became more elastic. The perirectal infiltration and exudate disappeared. The raw surfaces healed. The resistance to the examining finger diminished, and the strictures were easily dilatable. In addition to this favorable effect on the strictures, pronounced beneficial changes in the patients' general health were noted.

During the time of sulfanilamide therapy, our afebrile patients were allowed out of bed. Fluids were limited to 2,000 c.c. during twenty-four hours. Four Gm. of sodium bicarbonate in four divided doses were given daily. A regular diet was allowed, except during the period of the rectal administration of sulfanilamide, when a bland, non-residue diet was given.<sup>6</sup> The concentrations of sulfanilamide were determined by the method of Marshall, as modified by Marshall and Litchfield.<sup>7</sup>

CASE I. J. R., a 25 year old negress, was first seen on December 8, 1938, in the Out-

TABLE I  
FLUCTUATIONS IN HEMOGLOBIN (CASE I)

Date	Hemoglobin	Erythrocytes	Leucocytes	Polys.	Lymph.	Eos.
1/17/39	50	3,200,000	11,100	67	33	
1/21	..	.....	7,250	61	37	2
1/23	54	3,150,000				
1/24	56	3,350,000	9,950	74	24	2
1/27	57	.....	9,200	67	32	1
1/28	58	.....	6,700	69	28	3
1/29	58	3,210,000	11,850	62	38	
1/30	64	.....	6,650	50	48	2
1/31	64	.....	8,400	62	36	2
2/1	60	.....	10,950	74	26	
2/2	64	.....	6,300	55	43	2
2/3	62	.....	5,400	56	43	1
2/4	60	.....	13,000	73	27	
2/5	54	.....	6,200	68	32	

Patient Department of the Brooklyn Hospital, because of incontinence of feces, purulent rectal discharge, diarrhea, and dull pain about the rectum. These symptoms had been present since 1935, when she had had several rectal operations at a city hospital. During the previous year she had lost about 40 pounds in weight. Physical examination revealed poor nutrition, evidence of loss of weight, pale

mucous membranes, scarring in the anal and perianal regions, superficial fissures, a tight annular rectal stricture situated 4 cm. from the anus, perianal, perirectal and pericolic infiltration, and purulent discharge. The stricture was about 0.5 cm. in diameter, and could be stretched only with difficulty. The urinalysis was normal. Examination of the blood revealed secondary anemia. (Table 1.) The blood Wassermann test was negative. The Frei test, using two human antigens, was strongly positive. The sedimentation time of the erythrocytes was twenty-five minutes.

At various intervals of time, attempts were made to dilate the stricture with numbers 3 and 5 F. Wales rubber bougies, as well as with the index finger. At times, chilly sensations followed these dilatations.

On January 17, 1939, this patient was admitted to the Brooklyn Hospital because of fever ranging from 101 to 103°F. Colonic irrigations were given daily for four days because of the profuse rectal discharge. On January 21, a course of oral neoprontosil was begun, giving 0.6 Gm. per dose five times daily. Twenty-four hours later, the temperature dropped to normal. On January 27, the administration of sulfanilamide per rectum was begun after the preliminary determinations of the blood showed an absence of sulfanilamide. One hundred c.c. of 1 per cent of sulfanilamide solution were administered every four hours, day and night. At times parts of the medication were expelled. After the administration of 6 Gm. of sulfanilamide, the concentration of the blood was 4.5 mg. free and 2.5 mg. conjugated sulfanilamide per 100 c.c. After 12 Gm. had been given, 3.5 mg. free and 2.5 mg. conjugated sulfanilamide were found in each 100 c.c. of blood, and after the administration of 18 Gm. of sulfanilamide, the concentration of the blood was 6.5 mg. free and 1.5 mg. conjugated sulfanilamide per 100 c.c. For the ensuing three days, most of the medication was expelled.

At this time, examination revealed that the index finger was easily inserted through the stricture. On February 2, it was noted that the perianal and perirectal infiltration was disappearing and that the stricture had been favorably modified since admission to the Out-Patient Department. The rectal discharge and the diarrhea ceased after the rectal administration of 5 Gm. of sulfanilamide. The hemoglobin value increased gradually as shown in Table 1.

On February 2, sulfanilamide therapy by mouth was begun, giving 100 c.c. of 1 per cent solution every four hours, day and night. After the administration of 6 Gm., the concentration of the blood was 7 mg. free and 3 mg. conjugated sulfanilamide, and after a total of 12 Gm. of sulfanilamide had been given, 9 mg. free and 2 mg. conjugated sulfanilamide were found in each 100 c.c. of blood.

During the period of oral administration of sulfanilamide, the diarrhea returned, and continued for three days. The hemoglobin value gradually dropped. (Table 1.) However, the status of the anorectal disease continued to show improvement. Almost all of the perirectal and pericolic infiltration disappeared. The index finger could easily be introduced through the lumen of the stricture. The tissues were softer and more elastic. No pain was produced on rectal examination.

The patient was sent home on February 7, 1939, and was followed up in the Out-Patient Department. Oral sulfanilamide therapy, about 3 Gm. daily, was continued. On March 4, a sigmoidoscopy was performed. A regulation  $\frac{3}{4}$  inch sigmoidoscope was inserted with ease and caused no trauma. The mucous membrane was pale above the stricture. The site of the stricture was reddened. There was no infiltration palpable.

*Comment.* The striking response to sulfanilamide therapy in this case was remarkable. This response was far superior to any other therapeutic agent employed in our clinic in the past. It should also be noted that the hemoglobin values increased during the time sulfanilamide was administered rectally. When the same amounts of solution of the drug were given orally, the hemoglobin values began to decline. Also, during this time, there was a return of the diarrhea which continued for several days. These observations are worth noting, although at the present time we have no explanation for their occurrence.

CASE II. L. P., a 28 year old married negress, was seen in the Out-Patient Department on December 20, 1938, because of obstinate constipation, rectal tenesmus, intermittent rectal bleeding associated with dull pain, and the passage of narrow calibered stool. She had had syphilis two years before, for which she had

been treated extensively. Physical examination was essentially normal except for a soft annular rectal stricture, 5 cm. above the anus. There was moderate perirectal infiltration. The infant sigmoidoscope could not be introduced through the stricture. One week later, during an attempt to dilate the stricture with the index finger, a tear to the left occurred which was followed by bleeding. The stricture was thereafter dilated with number 5 F. Wales rubber bougie on several occasions.

A Gram stain of the purulent rectal material showed Gram-negative organisms, and *B. welchii*. No ova, parasites, amebae or tubercle bacilli were found. The blood Wassermann test was negative. The urinalysis was normal. The Frei test, using two human antigens, was positive. The sedimentation time of the erythrocytes was forty minutes. Cervical smear was negative for gonorrhea.

During the course of her illness, the patient was taken with acute abdominal pain, and on February 11, 1939, she was admitted to the Gynecologic Service of the Brooklyn Hospital with a diagnosis of acute salpingitis. The aperture of the rectal stricture at that time barely admitted the tip of the index finger. Under conservative treatment, including sulfanilamide tablets by mouth, her pelvic inflammatory disease gradually subsided.

On February 19, sulfanilamide therapy, using 1 per cent solution administered rectally, was begun. One hundred c.c. of this solution was given every four hours, day and night; the first midnight dose was omitted. Through an oversight, the preliminary determination of sulfanilamide in the blood was not done. After the administration of 6 Gm., the concentration of the blood was 5 mg. free and 4 mg. conjugated sulfanilamide, and after a total of 12 Gm. had been given, the concentration of the blood was 12 mg. free and 1.5 mg. conjugated sulfanilamide per 100 c.c. A temperature of 102.4°F. with a severe chill occurred. Sulfanilamide therapy was discontinued. The temperature remained at 102.4°F. the next day, and then dropped to normal.

On February 26, the patient was transferred from the gynecologic to the proctologic service. The gynecologists, in the transfer note, stated that the index finger passed the strictured area easily and painlessly.

On February 27, the rectal administration of sulfanilamide was resumed. Preliminary blood

tests showed no trace of sulfanilamide. After the administration of 7 Gm. of sulfanilamide, the concentration of the blood was 6 mg. free and 2 mg. conjugated sulfanilamide per 100 c.c.; after 12 Gm. (midnight dose being omitted), there were 6 mg. free and 1.5 mg. conjugated sulfanilamide; and after a total of 19 Gm. of sulfanilamide had been given, the concentration of the blood was 9 mg. free, and 2 mg. conjugated sulfanilamide per 100 c.c. No reaction was noted.

The patient was sent home on March 9, and has been followed up in the Out-Patient Department.

On several occasions Wales' rubber bougies, sizes 6 and 7 F., were easily introduced into the strictured areas.

*Comment.* This patient had a stricture with perirectal infiltration. The response to sulfanilamide was as good as in the first case.

CASE III. H. H., a 20 year old negro, was seen in the Out-Patient Department of the Brooklyn Hospital on February 1, 1939, because of large, tender inguinal, epitrochlear and posterior cervical glands. The left inguinal glands were considerably larger than those on the right side. Within three weeks, there was considerable swelling and central softening in the left inguinal region, and marked lymphadenopathy on the right side. He was otherwise normal. The past history included gonorrhea (?) which occurred five months previously and was self-treated. The urinalysis was normal. The blood Wassermann test was negative. The Frei test, using three human antigens, was strongly positive.

This patient was admitted on March 2, 1939. The bubo was aspirated, evacuating 20 c.c. of thick pus. Two days later the bubo was found distended, and tenderness continued in spite of a moderate escape of sanguinous fluid from the site of the needle puncture.

On March 9, a course of sulfanilamide therapy was begun. Two suppositories, each containing 0.5 Gm. of sulfanilamide, were given every four hours, day and night. After the administration of 7 Gm., the concentration of the blood was 1 mg. free and 1 mg. conjugated sulfanilamide per 100 c.c.; after 13 Gm. had been given, 2.5 mg. free and no conjugated sulfanilamide were noted (parts of the sulfanilamide were voluntarily expelled on two

occasions); after the administration of 19 Gm. of sulfanilamide, the concentration of the blood was 4 mg. free and 2 mg. conjugated sulfanilamide per 100 c.c.; and after a total of 25 Gm. had been given, 6 mg. free and 2 mg. conjugated sulfanilamide were noted for each 100 c.c. of blood.

Following the administration of 13 Gm. of sulfanilamide, the residual suppuration of the left bubo was subsiding, and the pain disappeared. The right lymphadenopathy regressed considerably after the administration of 19 Gm. of sulfanilamide.

Similar courses of sulfanilamide therapy were repeated, giving the same amount of the drug in 1 per cent solution first by rectum, and later by mouth. A total of 75 Gm. of sulfanilamide had been administered.

*Comment.* The third case is included to show that the inguinal (glandular) type of venereal lymphogranuloma also responds to sulfanilamide therapy. When the concentrations of the blood reached approximately 3 mg. of sulfanilamide per 100 c.c., the pain ceased and the residual bubo began to disappear. The inguinal glands began to regress when the concentration of the blood reached 6 mg. of combined sulfanilamide per 100 c.c. The action of sulfanilamide in this case suggests a specific effect because no secondary infection was present.

#### SUMMARY AND CONCLUSION

1. Sulfanilamide is very effective in the treatment of anorectocolonic and inguinal manifestations of venereal lymphogranuloma. Its action is most pronounced on the inflammatory and suppurative phases of this disease.

2. Intensive sulfanilamide therapy during the initial period of treatment is advised.

3. The concentration of sulfanilamide of the blood should be determined frequently during sulfanilamide therapy. We arbitrarily advocate a concentration of 5 or more mg. of free sulfanilamide per 100 c.c. of blood.

4. For reasons of safety and effectiveness, sulfanilamide therapy should prefer-

ably be given in a hospital. Daily medical supervision is essential for ambulatory patients.

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VARICOSITY of veins is perhaps most often due to increased intra-abdominal tension such as is caused by heavy labor.

From—"Circulatory Diseases of the Extremities" by John Homans (Macmillan).



# A COMPARATIVE STUDY OF SUBTOTAL AND TOTAL HYSTERECTOMIES\*

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THE relative merits of total and subtotal hysterectomy have long been a matter of controversy. It is obviously difficult to evaluate properly the advantages and disadvantages of each in a small series of cases performed by any one individual surgeon. Nor would it be of any value to select isolated cases from a group of individual operators. One of us<sup>1</sup> reviewed a series of cases at a private institution where there were only three operators. It is with this thought in mind that a statistical review was made of 550 consecutive hysterectomies performed by forty-eight different surgeons plus the resident staff, the latter working directly under supervision and closely following the technique of the attending gynecologist.

Before presenting the series of cases it would seem advisable briefly to review the current literature, especially those papers in which a relatively large series of cases are analyzed.

Siddall and Mack<sup>2</sup> have collected a series of cases from the literature comprising 7,795 subtotal and 4,559 total hysterectomies. To this series they added 1,141 cases of subtotal and 235 cases of total hysterectomy from one hospital. If to this group is added a series of cases reported by Gardiner and Kretschmar,<sup>3</sup> the total number of cases reported will be 9,606 subtotal hysterectomies and 4,985 total hysterectomies.

The combined ratio of total to subtotal is approximately 1:2 and the combined mortality is 3 per cent in the subtotal group and 3.56 per cent in the total group. This we believe to be a fairly representative group of cases seen throughout the country

in well organized hospitals of accredited standing.

A further analysis of the individual reports bring out some extremely interesting facts. From the analysis in Table I it

TABLE I

	Subtotal Hysterectomies		Total Hysterectomies	
	Number	Per Cent Mortality	Number	Per Cent Mortality
Masson.....	217	1.8	229	1.3
Nelson.....	122	3.2	476	2.9
Fullerton and Faulkner	609	4.4	1,078	4.1
Burch and Burch.....	166	4.2	32	3.1
Mayo and Mayo.....	3,085	1.2	1,588	1.8
Greenhill.....	1,857	4.47	551	4.72
Nead and Bill.....	1,739	2.1	605	3.1
Siddall and Mack.....	1,141	2.6	235	6.4
Gardiner and Kretschmar.....	670	3.1	191	4.7
Total.....	9,606	3	4,985	3.56

appears obvious that the greater the number of total hysterectomies done in any one series, the lower the mortality (with the exception of the series reported by Burch and Burch). It would seem only logical to assume that the greater skill developed by performing an increasing number of total hysterectomies would diminish the mortality percentage on a

TABLE II  
WOMAN'S HOSPITAL SERIES

	Subtotal	Total
Number of cases.....	350	200
Youngest.....	23 years	23 years
Oldest.....	68 years	62 years
Average.....	38.5 years	39 years
Number of operators 48		

\* From Woman's Hospital, Detroit, Michigan.

technical basis. It would certainly not deter the surgeon from the procedure because of relative unfamiliarity, provided other considerations were equal.

The average age in both groups is for all practical purposes the same. The number of individual operators is sufficiently large and varied in gynecological experience and skill to permit a fairly accurate general interpretation of the subsequent statistical tables.

TABLE III  
SYMPTOMOLOGY

	No. of Cases	Percentage
1. Bleeding	242	48 0
2. Abdominal pain	170	30 9
3. Abdominal mass	61	11 1
4. Backache.	40	7 3
5. Frequency	20	3.6
6. Procidencia	6	1 1

The symptoms presented were mainly bleeding, abdominal pain and abdominal mass. These symptoms were present either singly or in combination in approximately 90 per cent of all cases. The most common symptoms were vaginal bleeding—48 per cent; abdominal pain—30.9 per cent; and abdominal mass—11.1 per cent. Other less constant symptoms were backache, frequency and procidentia.

TABLE IV  
ANESTHESIA

	Subtotal		Total		Combined	
	No.	Per Cent	No.	Per Cent	No.	Per Cent
Gas-ether.	307	87 4	150	75	457	83
Spinal	35	10	21	10	56	10 2
Avertin.	6	1 8	29	14 5	35	6 3
Gas	2	0 76	0		2	0 36
Average duration of operation	1 hour 15 minutes		1 hour 18 minutes			

In the entire group the anesthetic use in 83 per cent of the cases was gas induction and ether. Spinal anesthesia was used in 10.2 per cent; avertin as a basal anesthetic in 6.3 per cent, and in only two cases, or 0.36 per cent, was gas alone used. It is interesting to note that in the choice of anesthesia, the percentage of the individual anesthetics employed in each group is practically alike, except in the use of an avertin basal anesthesia. This was used in

five times as many total as subtotal cases. Whether the use of avertin had any effect on the immediate postoperative morbidity one is unable to state definitely. It should, however, be noted that the patients required closer observation during the first twelve postoperative hours.

As to the duration of operation, only three more minutes on the average were required to complete the operation of total hysterectomy as compared to subtotal. Certainly the time element is of no great significance, and should not be an influencing factor in deciding against total hysterectomy.

TABLE V  
ADNEXAL AND ADDITIONAL OPERATIONS

	Subtotal		Total		Subtotal and Total	
	No.	Per Cent	No.	Per Cent	No.	Per Cent
1 Bilateral salpingo-oophorectomy	100	28 9	76	38	176	32
2 Unilateral salpingo-oophorectomy	70	17 1	66	33	136	24 7
3 Salpingectomy	14	4	4	2	18	3 3
4 Oöphorectomy	22	6 2	6	3	28	5 1
5 Appendectomy	208	59 7	108	54	316	57 4
6 Dilatation and curettage	24	6 4	10	5	34	6 2

In the entire group additional adnexal operations were done in 65.1 per cent. In the subtotal group alone, these operations were done in 56.2 per cent. Of these 35.1 per cent had all ovarian tissue removed. In the total group 76 per cent had adnexal operations, but only 41 per cent had all ovarian tissue removed. Although 19.8 per cent more of the total group had adnexal operations, only 4.9 more in this group had all ovarian tissue removed.

The percentage of appendectomies in both groups is higher in the subtotal group, but since these were prophylactic measures one can attach no significance to this.

In the subtotal group 8 per cent of the cases developed complications, while in the total group 13.5 per cent developed complications. Patients in the total group had 19.8 per cent more adnexal operations as compared to the subtotal group. This undoubtedly has some direct effect on the morbidity, although one is unable to make this assertion upon sound scientific basis.

Peculiarly enough, there were five cases of postoperative shock in the subtotal group. Obviously then, in this series postoperative shock is not an important deciding factor, since this complication occurred at least as often in both types of operation.

However, when we consider pulmonary embolus, it is found that whereas only two cases in the subtotal group were involved, in the total group five had this serious complication. Some writers have reported more cases of pulmonary embolism in the subtotal group and they believe that there is less venous trauma in the total group where more of the veins are excised.

In the subtotal group one patient developed a troublesome cystitis and in one case the bladder was opened at the time of operation. In the total group, while there were also only two complications involving the genitourinary tract, they were of a more serious nature, a bladder fistula and a bladder and rectal fistula. Although much mention is made of the fact that the total operation endangers the bladder, ureters and rectum, in this series this complication was encountered only in two cases, or 1 per cent, and not in a single instance were the ureters damaged.

Minor postoperative vaginal bleeding occurred in two of the total group, both on the second postoperative day. There was none in the subtotal group.

While only one case of pelvic peritonitis is listed in the subtotal group, it is well to note now that in the mortality table there are two cases of generalized peritonitis in each group with fatal termination.

The other complications listed are not peculiar to either type of operation, but rather to abdominal surgery in general, and do not hold any special significance.

The average stay in the hospital was only 0.6 day more in the total group than in the subtotal group.

The temperature peak in both groups was reached on the first or second postoperative day and subsided gradually to normal on the fourth or fifth postoperative

day. The average highest temperature was only 0.2 per cent of a degree higher in the total group than in the subtotal group.

TABLE VI  
MORTALITY—LISTED CAUSES OF DEATH

	Entire Series	Total	Subtotal
Peritonitis.....	4	2	2
Evisceration.....	2	0	2
Malignancy with metastasis.....	1	0	1
Pulmonary embolus...	1	0	1
Paralytic ileus.....	1	0	1
Cardiac failure.....	2	2	0
Anuria with nephritis..	1	1	0
Total.....	12	5	7

In the entire group of 200 total hysterectomies there were only two deaths due to peritonitis, or 1 per cent mortality. This mortality is not particularly high in view of the pathology of the tissues involved, and does not necessarily bear out the contention that opening the vaginal vault predisposes to peritonitis. An equal number of fatal peritonitis cases was encountered in the subtotal group, although the percentage of mortality here was somewhat lower, 0.6 per cent. The other fatal complications cannot be classed as contraindicating either one or the other type of hysterectomy. Thus two fatal cases of evisceration occurred in the subtotal group, and two cardiac deaths in the total group. The death due to anuria with nephritis is interesting, more from the view of previous antiluetic therapy and its relation to anaesthetic rather than to the choice of surgical procedure. There was no damage to the ureters during the surgical procedure, and so it cannot be considered as a complication peculiar to the procedure carried out.

#### DISCUSSION

From the cases analyzed in the literature and the series of cases from Woman's Hospital, certain factors lend themselves to generalization.

The mortality and morbidity in total hysterectomy is slightly higher than in subtotal in a general hospital with a large group of operators. The total operation as such must therefore be considered a more formidable procedure. Yet it has been shown that the more frequently this procedure is employed and the more familiar

the surgeon becomes with the operation, the lower the mortality.

To guard against the possibility of coexisting carcinoma, a routine vaginal preparation is of the utmost importance. Under anesthesia and ideal operating room facilities it is only a matter of a few minutes to reexamine the patient and whenever indicated to do a diagnostic curettage and frozen section.

It has been stated that the cervical stump is necessary to act as a keystone of the arch to prevent prolapse after hysterectomy. Actually this is a rare occurrence following total hysterectomy providing the round ligaments are properly suspended. With regard to leucorrhea and backache, Nelson<sup>1</sup> has encountered less difficulty with these troublesome sequelae in his total group than in the subtotal group, and Gardiner and Kretschmar<sup>3</sup> report a 7 per cent higher incidence in the subtotal as compared to the total group.

It is not the purpose of this discussion to advocate the use of total hysterectomy rather than subtotal and vice versa. Rather it would be well to emphasize that in view of the above considerations total hysterectomy is not so formidable as to greatly limit its more general utilization. The general physical condition of the patient, the pathology present and the age must always be influencing factors, even to the surgeon who is equally familiar with both procedures.

Richardson<sup>7</sup> refers to the types of cases that are suitable for subtotal hysterectomies, as:

1. Those women requiring hysterectomy for benign disease who possess perfectly normal cervixes.

2. Those instances in which the operative hazard compels the execution of conservative surgery.

3. Those cases where, for good and sufficient reasons, it is of paramount importance to preserve the menstrual function.

4. Most cases requiring hysterectomy during pregnancy.

These are factors well worth pondering. It would also appear advisable to consider the endocrine status of the patient following subtotal or total hysterectomy and its relation to the onset of menopausal symptoms. It has been shown that the normal woman in going through her menopause has an increase in her blood prolactin and a decrease in blood estrin. Marx, Catchpole and McKennan,<sup>4</sup> working with a series of twenty-one clinical patients, after a

careful and detailed study showed that the patient who had a total hysterectomy is more likely to undergo her menopause at an earlier date than the patient who had a subtotal hysterectomy. It is their belief that the uterine endometrium elaborates a catalytic principle acting on the pituitary-ovarian hormonal mechanism, regulating its normal balance and functional harmony. This phase of the problem is extremely interesting, and like all endocrine studies, additional work with a larger group of patients should be conducted before definite conclusions can be drawn.

#### CONCLUSIONS

1. A series of 550 abdominal hysterectomies from the Woman's Hospital is presented. The cases covered a period of 4½ years and included 350 subtotal and 200 total hysterectomies.

2. This series shows a slightly higher mortality and morbidity for the total group. It must be borne in mind, however, that the difference is not sufficiently great to justify a decision against this procedure where there are indications for its use.

3. The total hysterectomy should be more frequently done in those cases where the cervix shows signs suspicious of pre-malignant states. Only too frequently is a malignancy of the cervix encountered shortly after subtotal hysterectomy. Undoubtedly there was a coexisting early malignancy of the cervix at the time of operation.

4. Clinical follow-up in the total group with relation to the endocrinological disturbances caused by removal of the cervical stump needs further study.

5. This problem should not be considered in the light of total versus subtotal hysterectomy.

It would be much better for the surgeon equally familiar with both procedures to employ the one which appears to be indicated in each individual case.

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PROLAN (from the chorionic cells of the human pregnant uterus), the gonadotropic hormone characteristic of pregnant-mare serum (likewise probably secreted by chorionic or endometrial cells), and the gonadotropic hormones of neoplasms such as hydatidiform mole, chorionepithelioma, and testicular tumor (from the cells of the neoplasm) . . . appear not to be secreted by the hypophysis.

From—"The Physiology and Pharmacology of the Pituitary Body," vol. II, by H. B. Van Dyke (University of Chicago Press).

# TREATMENT OF DYSMENORRHEA\*

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A WOMAN is said to be suffering from dysmenorrhea when the subjective manifestations of the menstrual period are so exaggerated that she complains of marked pain or discomfort in the lower abdomen and pelvis, thighs, or sacral region. Severe dysmenorrhea is often accompanied by such symptoms as headache, eye-strain, contraction of the field of vision, cutaneous eruptions (acne and eczema), and neuralgic conditions (toothache and joint pains).

We will consider here only the treatment of severe dysmenorrhea. The ordinary cases where almost any antispasmodic or analgesic affords relief are not within the scope of this paper. Our results were obtained by the use of corpus luteum extract in oil, and anterior pituitary-like hormone made from pregnancy urine. The treatment of severe dysmenorrhea has never been uniformly successful.

Boynton used calcium gluconate and obtained complete relief from abdominal pain, leg cramps, paresthesias and nausea in thirty-three out of forty-nine cases treated. The calcium gluconate was given in 60 gr. doses daily for two weeks before the onset of the menstrual period; when viosterol was added, 30 drops daily was given.

De Benedetto claims very good results from the use of bellergal, said to contain phenobarbital 0.02 Gm.; ergotamine tartrate 0.00003 Gm.; levorotatory belladonna alkaloids 0.0001 Gm. The patients were

directed to take orally one tablet with water every two hours but not to exceed five or six tablets in any one day. Treatment began with the onset of pain and was continued, if necessary, during the first day or two or throughout the entire period. Rest and particular attention to elimination were observed. In thirty cases, the menstrual pain was completely abated within six hours after the first administration of the tablets. In twelve cases, it was necessary to continue the treatment during the first two days of the menstrual flow. Treatment was required in ten cases throughout the entire menstrual period. Headache, in varying degrees of severity, was also completely relieved by the therapy.

Cary has used a new non-narcotic synthetic antispasmodic agent which apparently has the useful qualities of both atropine and papaverine with the disadvantages of neither. This is the 3-diethyl-amino-2, 2-dimethyl-propanol ester of tropic acid and is marketed under the trade name of syntropan in the form of 50 mg. tablets. In animal experimentation, Fromherz tested the antispasmodic action of syntropan on the isolated rabbit intestine against the stimulating effect of acetylcholine, and on the isolated rabbit uterus against the action of epinephrine. He found that the relaxing effect upon the intestine is five times stronger than that of papaverine. Only very small doses were needed to produce complete relaxation of

\* Read before the Brooklyn Gynecological Society, April 1, 1938.

the intestinal musculature following acetylcholine stimulation. Syntropan acted similarly to atropine as an inhibitor of the parasympathetic division of the autonomic nervous system, and thus tended to reduce excitatory states of smooth muscle. Pharmacologic studies of Fromherz and others demonstrated that in therapeutic dosage the antispasmodic effect of syntropan corresponded to that of atropine but that its use was free from disagreeable by-effects on circulation, the pupil and glandular secretion which too often attended the administration of atropine.

In fifteen cases, pain varied from moderate to severe. Single, married, and widowed women were included in the series. Ages ranged from 27 to 40 years. All cases were apparently benefited, 60 per cent returning to normalcy, 40 per cent being improved. Medication was instituted twenty-four hours preceding onset of the menstrual period and then continued for the first day of the period. Remission of localized uterine pain was not the sole benefit derived from treatment; other constitutional symptoms disappeared.

Altschul reported twelve cases of dysmenorrhea occurring mostly in patients below par physically, underweight, and often with low basal metabolism, which he treated with insulin, 7 to 10 units daily, either at the time of the pain or over a period of three days prior to the menstruation, with almost total relief from pain in ten, partial relief in one, and relief in one of two periods in the twelfth case. Blood sugars in these patients were normal.

Watson treated 105 cases of dysmenorrhea with the placental extract, emmenin. Of these, forty-nine were completely relieved, the benefit lasting as long as six months after cessation of treatment in twenty-one of these cases. In twenty-seven patients relief was experienced to a degree which enabled them to overlook the remaining discomfort. In twenty-nine cases there was no amelioration obtained. Best results were gotten when three teaspoons of emmenin were given two weeks prior to the

menstrual period. Emmenin is a powerful estrogenic substance present in acetone extracts of human placentae, alcohol-soluble, ether-insoluble, active orally, though relatively inert in oöphorectomized animals.

Witherspoon obtained relief from dysmenorrhea in thirteen of seventeen patients treated by injection of 250 rat units of follutein intramuscularly daily, for three to four days previous to the expected flow. The luteinizing principle found in the urine of pregnant women is believed responsible for the results obtained.

Israel, reporting on thirty-nine cases of severe dysmenorrhea, obtained relief in four of ten cases with antuitrin-S, 200 rat units being given every other day for from two to three months; in three of ten cases with emmenin, one tablespoonful (75 day-oral units) three times a day from three to five months; in one of six cases using progynon 600 rat units three times daily for three to four months; and in ten of thirteen cases using 5,000 to 10,000 rat units every fourth day for three to four months. In the last group, four were relieved for at least two to four months after withdrawal of the medication and six while continuing the injections, but none were permanent cures. Up to 200,000 and 3,200,000 rat units of progynon were tolerated well by this last group of patients.

Work with benzedrine for the relief of dysmenorrhea has already been begun, without any published reports as yet of the results.

Bauer administered pitressin to six patients with dysmenorrhea, 0.5 c.c. at the beginning and during the period of the pain, and obtained partial or complete relief. Immediately after injection there was a temporary increase in the cramps, probably, he stated, due to the small amount of the oxytocic fraction in the preparation. The blood pressure was carefully watched during this procedure and at no time was a dangerous rise observed. He does not state the effect on the gastrointestinal system. Reynolds showed that uteri in a state of contraction induced by

calcium became relatively quiescent three or four minutes after injection of 0.5 c.c. of pitressin and were refractory to subsequent injections of calcium or pitocin unless the uterus was again motile. Moreover, it was frequently observed that pitressin for a time abolished the spontaneous contractions of the uterus and rendered this organ transiently refractory to both calcium and pitocin. Bauer used antuitrin-S in several cases, in 1 c.c. doses, at various intervals during the second half of the menstrual cycle, and obtained relief of moderate degree in one case.

Emge found theelin to be of aid in dysmenorrhea in only six of twelve cases, and of these four improved only moderately. He believes that vaginal suppositories containing acetanilid, sodium borate, zinc borate and hydrastin, in glycerogelatin, brought the best results. Thyroid gave relief in eight cases, partial in six, and no benefit in four. Thyroid was given after a basal metabolism test, and the clinical evidences of the patient, namely, fatigue, obesity, and sluggishness showed the presence of thyroid insufficiency.

Kennedy, using progynon, sistomensin, and ampacoids and ovacoids, obtained complete relief in ten cases, improvement in thirty, and no amelioration in ten. Dosages were not stated. Occasionally pessaries were substituted for the injections. He based his reasoning on the fact that ovarian hormones aid restoration of the cervical ganglia of the cervix to normal. Previous investigation showed that after ovariectomy the cervical ganglia suffer in that the Nissl granules are lysed, the cells shrink, while the number of chromaffin cells always associated with the ganglia diminish markedly. Restitution of the original picture was obtained by the injection of estrin, and maintained by repetition of the administration.

Tunis reported a series of seventy-eight cases in which he used menformon, an estrogenic preparation. These women had dysmenorrhea associated with hypoplastic uteri. Excellent relief was obtained in

sixty-five cases; eight patients were improved and five were refractory to treatment, which consisted in six injections of 1,000 units each.

Hacker reports a case in which excellent results were obtained from corpus luteum, even when given by mouth. This relief continued for months at a time, but with recurrence of pain sooner or later. Following a suspension operation for retroversion of the uterus, there was relief for a year. The use of 1,000 Allen-Doisy units ten days prior to menstruation for three months brought complete relief.

The uterus of the experimental animal is in a state of motility, and definite contractions can be recorded when the animal is in a state of estrus. Under the influence of the animal's own corpus luteum the uterus becomes quiescent, no contractions can be elicited, and it is refractory to pituitrin. Knaus' and Reynolds' work concur on this point. On the day before the onset of menstruation the uterus reverts to its preovulatory behavior, which may help explain some dysmenorrheas.

Wintz used sistomensin in 125 cases of dysmenorrhea, giving 5 c.c. daily for several days prior to the menstruation. He obtained complete relief in eighty-two cases, improvement in fifteen, and no effect in twenty-eight.

Elden and Wilson, using progestin, obtained complete relief from dysmenorrhea in 47 per cent of seventeen patients, partial in 12 per cent and none in 41 per cent. The patients were normal women with normal pelvic findings. The dosage used was  $\frac{3}{25}$  to  $\frac{6}{25}$  units, the amount being given in divided or single doses three to six days before the menstrual flow or before the onset of pain. It was given at this time because of Knaus' observation that the uterus reacts to pituitrin the day before the onset of bleeding and because the hormone is in oil and therefore slowly absorbed. There was no delay in the onset of the menstrual cycle, and apparently no change in the duration of the flow. Several of the patients who



experienced no relief received larger doses, up to 1 unit. Two of these patients had subsequent presacral sympathectomies with complete relief. Two patients received estrogenic hormone up to 50,000 international units with little effect.

Hisaw and Campbell have used the preparation corporin, a pure chemical product of the corpus luteum hormone alone. They confined their therapy to a definite class of dysmenorrhea patients with normal genital development and placement. Patients with infantile genital development, cervical stenosis and improper drainage, ovarian abnormalities, or other extragenital conditions which might cause the periodic pain, were excluded from their series. Of five patients, four found complete relief and the fifth moderate ease. Their dosage was 5 to 8 rabbit units daily for five days prior to the menstrual period. Two patients flowed more than ordinarily after several series of injections.

We are here reporting ten cases of severe dysmenorrhea, not apparently associated with any specific cause, the so-called essential dysmenorrhea. Histories of several cases are appended.

M. L., age 24, single, had always suffered with severe pain and cramps at the menses, which began at 12 years, were moderately heavy in amount of flow, and recurred regularly each month. The patient was bedridden at least every other menstruation. Rectal examination revealed no pelvic abnormalities. Estrin excretion was 32 units per day with a strong positive pituitary prolan reaction.

This patient received  $\frac{1}{2}$  international unit of progesterone every other day for ten days prior to the period, and had absolutely no pain. The following month she was given the same treatment, but the period being delayed, the treatment was continued for about  $3\frac{1}{2}$  weeks. This period was also devoid of any pain. There was delayed flow the following month and the same excellent result from treatment. The patient has required no further injections. The menses have regulated themselves, and nine months later there had been no recurrence of the severe dysmenorrhea.

R. P., age 28, married, gave a history of severe dysmenorrhea for about ten years, both prior to and since her marriage three years ago. A previous dilatation and curettage effected only a very temporary beneficial result. Her periods were regular, of five days' duration, and accompanied by such pain that the patient took either several injections of morphine, or a large amount of alcohol to deaden the pain.

This patient was very coöperative and intelligent. Anterior pituitary-like hormone, 100 units, was given three times weekly for one month, with marked exaggeration of the symptoms. Since it was possible to gauge accurately the onset of cramps,  $\frac{1}{2}$  to 2 units of progesterone was given about twelve hours prior to the pain with almost entire relief. This was repeated each month for seven months; then two months were allowed to elapse without treatment, and without any pain. It was then necessary to renew treatment. An endometrial biopsy was attempted premenstrually and a tight cervical stenosis was found. A glass stem pessary was inserted, which resulted in disappearance of pain for a few months. Scant endometrium was obtained on curettage and was reported as progestational in character.

G. W. age 26, married fifteen months, gave a history of dysmenorrhea for ten years. Her periods were regular, but with menorrhagia and dysmenorrhea. The right breast was larger than the left, and a tumor had been removed from it a year before. The uterus had a small fibroid in its lower segment. The patient was sterile and biopsy of the endometrium showed no progestational changes. Hormone determinations disclosed 8 units of estrin, and a negative prolan reaction. She was given  $\frac{1}{5}$  unit of progesterone every three days for ten days premenstrually during three months. No dysmenorrhea or menorrhagia has occurred since. She was delivered of a normal child nine months after the cessation of treatment.

C. P., age 19, complained of dysmenorrhea since the onset of menses, which, however, occurred regularly. The uterus was normal upon rectal examination and no adnexal pathology was found. The dysmenorrhea increased with time. Acne, comedones, and mild hirsutism were present. Basal metabolism was minus 10. Estrin and prolan determinations were normal. Pain in the breasts was present twenty-four hours premenstrually, and abdominal pain for three days before bleeding. Progesterone

$\frac{1}{5}$  unit was given every 3 days, ten days premenstrually for four months. There has been no dysmenorrhea since. The acne has disappeared. There was no effect on the hirsutism.

A. M., 31 years old, married, had one child five years previous. This patient had menorrhagia for three and one-half years after childbirth, and in addition, dysmenorrhea for the past one and one-half years. Hormone studies were normal. Treatment with  $\frac{1}{5}$  unit of progesterone every three days for ten days premenstrually was instituted. The menorrhagia and metrorrhagia stopped in two months, the dysmenorrhea in four months. In fourteen months since cessation of treatment there has been no return of pain or excess bleeding.

F. B., age 25, single, had a history of increasing dysmenorrhea for five years. Rectal examination revealed no pelvic pathology and hormone determinations were normal. Anterior pituitary-like hormone given in 1 c.c. doses every other day during the last half of the cycle for four months, gave relief from the severe pain and it was possible to discontinue treatment for several months without any recurrence.

R. L., age 21, single, had dysmenorrhea since onset of menses at the age of 14. The genitalia were apparently normal. Anterior pituitary-like extract injected, 1 c.c. twice a week during the second half of the cycle, brought about complete relief. Treatment was continued for three months, and pain has not recurred since discontinuance of medication over a year ago.

#### SUMMARY

Almost all types of hormones have been used in treating dysmenorrhea, with good

results in a considerable percentage of cases.

Hormone determinations have only occasionally been of value as a determining factor in treatment.

Endometrial biopsy is a valuable aid in the determination of the state of uterine and ovarian activity.

In our series of ten cases, eight were benefited either partially or completely by administration of corpus luteum hormone, and two were aided by anterior pituitary-like hormone. One patient helped by progesterone was definitely made much worse by anterior pituitary-like hormone.

We wish to express our appreciation for the coöperation accorded us, and the material supplied for the above work, by the Schering Corporation (Proluton—corpus luteum hormone), Winthrop Chemical Co. (Antophysin—anterior pituitary-like hormone), and E. R. Squibb (Follutein—anterior pituitary-like hormone).

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# THE EFFECT OF A BUFFER OF MANDELIC ACID AND ESTROGENIC HORMONE IN THE TREATMENT OF TRICHOMONAS VAGINALIS VAGINITIS\*

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IT would seem superfluous to add another contribution to the long list of articles concerning the eccentricities and behavior of the trichomonas vaginalis, unless very definite data of etiologic and therapeutic import could be presented. The sole purpose of this paper is to make a few observations regarding the rationale of therapeutic application in this infection and add another chemical agent to the already long list.

The majority of investigators in this field seem to believe that the source of the infection is from the intestinal tract. The protozoan is harbored there, apparently in an innocuous state, as no pathologic condition of the intestines has been attributed to it. The close proximity of the rectum to the vagina makes for easy transmission of the organism. When entrance is obtained the behavior of the trichomonad may be harmless, but it may induce, under proper conditions, an inflammation of the vagina. The inflammatory reaction produces small superficial ulcerative lesions of the vaginal walls and cervix (portio) that result in a profuse yellowish discharge, which microscopically consists of numerous pus cells, a limited number of epithelial cells, and many trichomonads in an active state of motility. The discharge as a rule is quite profuse, may have a disagreeable odor, and produces an irritation and itching of the vulva that continues in spite of the ordinary vaginal douches taken. To the patient suffering from this infection is imparted not only physical discomfort, but a mental depression due to the sensation of uncleanness.

Treatment of this condition has endeavored to destroy the organism through the use of different chemical agents. Many preparations have been used, and while they have been helpful and have effected cures, there is much left to be desired as to a definite specific outline in establishing better results.

The trichomonad is sensitive to most chemical substances and seems easily destroyed following the usual therapeutic measures. However, in a large percentage of cases, recurrences are encountered. This is quite characteristic and occurs in spite of thorough investigation of the sources of reinfection, from the urethra and bladder urine and the semen of the consort. Much has been written concerning the treatment of recurrent attacks, which really seems to be the crux of the problem.

Some underlying factor of a biochemical nature is evidently at fault. Along these lines, many observations concerning the behavior of the trichomonad in the vagina have been made. In the first place, the vagina can harbor these organisms without pathologic reaction of the tissues. The vagina also may apparently be free of the trichomonads, but as menstruation approaches positive specimens are seen. In view of this observation it has been thought that the trichomonads were harbored in the uterine cavity and were active just before and during the menstrual flow. I have taken many specimens from the uterus and cervix of such patients and have failed to find a positive specimen.

We do know that the reaction of the normal vagina is acid, with a pH of 4 to 4.5;

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that microscopically a smear will show over 95 per cent epithelial cells, some mucus, occasional pus cells, and many Döderlein bacilli.

Interesting observations have been made by Dobszay<sup>1</sup> as well as by Cruickshank and Sharman<sup>2</sup> concerning the vaginal secretions of infants and children. In the newborn the reaction of the vaginal secretions was found to be acid and the Döderlein bacillus was evident. This state continued for seven to ten days. Their explanation for this reaction was assumed to be due to the continued action of the maternal estrogenic hormone absorbed through the placental circulation in utero. After the tenth day following delivery, the estrogenic hormone having been excreted, the vaginal secretions became alkaline without the presence of the Döderlein bacillus and continued in this state through childhood. At puberty and adult life the acidity and the presence of the Döderlein bacillus were the prevailing characteristics of the vaginal secretions. At and following the menopause there is a reversion to the prepubertal condition of alkalinity. The presence of the Döderlein bacillus is important, as its function seems to be to maintain the normal acid reaction of the vaginal secretion by its action upon the glycogen of the vaginal epithelium. We also know that in trichomonas vaginitis there is a complete disappearance of the bacillus in pronounced and severe cases. Only a few remain in the the milder types, or in patients rapidly improving under treatment. In the severe forms of the infection the reaction of the vaginal secretion leans toward the alkaline side with a pH of 5 to 6.5 and sometimes 7.0.

According to Karaky,<sup>3</sup> this is due to a deficiency of glycogen in the vaginal epithelium. Normally the Döderlein bacillus acts upon the glycogen to produce lactic acid, thus maintaining the normal acidity of the vagina. I am much in accord with Karaky. In the successful treatment of these infections, the basic aim of therapy should be to lower the vaginal pH, thereby

increasing and establishing a higher acidity of the vaginal secretions. To produce this favorable condition, the introduction of a substance having a pH of 2.0 to 3.0 would overcome the alkaline tendency and bring about an unfavorable soil for the growth of the trichomonad and associated bacteria.

In selecting such a chemical it seemed necessary to choose one that was not irritating to the vagina. As mandelic acid seemed to be so successful in the treatment of renal and bladder infections by rendering the urine highly acid, destroying the bacterial flora and preventing their propagation and growth, we decided to apply it to this type of vaginal infection. It has been a much discussed point whether the Streptococcus subacidus is the real culprit in producing the local lesions and symptoms in trichomonad infestations, as it is so frequently encountered in specimens and cultures from the vagina of those suffering from the disease. This was another reason for trying mandelic acid in the condition. This drug has been markedly successful in streptococcus infections of the urinary tract. It seemed desirable to endeavor to maintain the lowered pH of the vaginal secretion following the therapy with mandelic acid buffer.

The administration of estrin to patients with senile vaginitis is practically a specific for the healing of the superficial ulcerations. It was thought that it might aid in a similar manner in trichomonas vaginitis lesions, at the same time increasing the acidity of vaginal secretions and antagonizing the growth of the organism. In conjunction with sodium mandelate insufflations, therefore, injections of 30,000 international units of estrogenic substance were given three times weekly. This idea was suggested by the work of Lewis and Weinstein<sup>4</sup> in their investigations of gonorrheal vulvovaginitis of children. They found that the normal vaginal reaction in children was alkaline (pH 7.2) and that the secretions were free of the Döderlein bacillus. In gonorrheal vaginitis the reaction showed a pH that was neutral. The estrogenic

hormone caused the vaginal reaction to become acid, with disappearance of the gonococci in a surprisingly short time.

To evaluate and apply these findings in patients with trichomonas vaginalis infestation, a group of patients were selected who suffered from severe and pronounced symptoms of vaginitis, profuse yellow discharge and aggravated pruritus. Microscopic examination showed numerous motile trichomonads. The vagina and portio gave evidence of the characteristic lesions of superficial ulcerations that bled easily when wiped with a cotton ball. Biopsies from these areas were reported as typical. The reaction of the vaginal secretions was neutral or slightly acid, ranging from 5.5 to 7.0.

These patients received 30,000 I. U. of estrogenic substance three times weekly, given intramuscularly in the gluteal region. No other form of therapy was prescribed except a daily cleansing vaginal douche of normal saline solution. The vaginal reactions were carefully taken and the secretions examined at each treatment. These patients were observed over a period of months and in every instance there was a cessation of the vaginal discharge and complete disappearance of the pruritus with resolution and involution of the vaginal and cervical lesions. This occurred when the reaction of the vaginal secretions became increasingly acid, 3.5 to 4.5 pH. However, in only a few instances when the vaginal pH became very low, 3.0 to 3.5, did the trichomonads disappear. This would lead one to infer, as other observers have, that the trichomonads of the vagina do not become pathogenic except in a soil that becomes fertile in a mildly acid or alkaline medium. I think this explains the recurrences in some instances when the vaginitis lightens up at the menstrual epoch, at which time the secretions become definitely alkaline. It may also explain how difficult it is, irrespective of the form of local therapy, to clear up these infections in the presence of a chronic endocervicitis, where the cervical discharge is alkaline. When

appropriate destructive treatment is applied for the cervical inflammation, good results in the treatment of the vaginal infection can be expected.

A larger group of patients (fifteen) were selected at random from the clinic in order to study the local effect of a highly acid substance insufflated into the vagina. A buffer of mandelic acid was prepared by mixing a concentrated solution of sodium hydroxide with mandelic acid in molecular proportions. This was stirred until dissolved, then the water was evaporated. The residue was washed with ether to eliminate any remaining mandelic acid. The result was a mass which can be pulverized. To this powder of sodium mandelate was added mandelic acid and glucose in the following proportions:

4.29 Gm. of sodium mandelate  
3.16 Gm. of mandelic acid  
1.00 Gm. of glucose

This is well mixed and put up in receptacles of 2 Gm. each. The pH of this buffer is 3.0.

The vaginal secretions of the second group all showed a positive trichomonas infection of varying degrees and the reactions varied from 4.5 to 6.5. The mandelic acid powder was insufflated three times weekly, and no other form of local therapy was prescribed. These patients were carefully observed for the presence or absence of the trichomonads, the pH was meticulously recorded at each clinic visit, and the vaginal secretion examined. Following six insufflations, the entire group became free of the trichomonads, with a lowering of the pH to 3.5 to 4.5.

When this occurred the local treatment was discontinued and the patients were given injections of estrogenic hormone 30,000 I. U., three times weekly for a period of three weeks, or nine injections in all. They were observed for three weeks after the last injection.

In two instances during this period of observation two recurrences of positive trichomonas were seen, but without the subjective symptoms that were a former complaint. Careful investigation of the

urinary tract did not disclose any trichomonads in the bladder or urethra. It might also be said that in this series, examination of the rectum and specimens obtained from it did not show the presence of the trichomonas. It would seem that this protozoon acquires ready access to the vagina and lives there for a long time under favorable and unfavorable conditions, and in some instances is most difficult to dislodge.

#### SUMMARY

*Trichomonas vaginitis* is an infection induced by the *trichomonas vaginalis*, probably by contamination from the intestinal tract. The presence of the trichomonad in the vaginal secretion does not mean necessarily a pathogenic process because in many instances there is no discharge nor are there typical lesions of the vagina and cervix showing the presence of such an infection. When the vaginal secretion changes from the acid to the alkaline side conditions are rendered more suitable for the growth and pathogenicity of the trichomonad. This may occur when the entire body tissues are at a low resistance, as in anemia, subglandular dyscrasias, and at menstruation.

The treatment should be to build up the general body resistance by administration of iron tonics and vitamin therapy and at the same time to attempt to produce an acid reaction of the vaginal secretion, as the trichomonad does not thrive in the presence of a pH of 3.0 to 4.0. This can be done by insufflating the vagina with a mandelic acid buffer. The injection of estrin in 30,000 I. U. doses three times weekly is a splendid supplement in maintaining the acid reaction of the vagina, in aiding the reappearance of the Döderlein bacillus, increasing the glycogen content of the vaginal epithelium, and in destroying the trichomonads or rendering them non-pathogenic.

I should like to thank Dr. S. Piracci of the Italian Drugs Importing Company for the supply of estrogenic substance (ectofollicolina).

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# ABORTION AS A COMPLICATION OF OPERATION IN THE PREGNANT WOMAN

## A PLEA FOR THE PROPHYLACTIC USE OF PROGESTERONE

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THE danger of abortion resulting as a complication of surgical procedures in pregnant women is ever present, particularly when the necessary surgery is on the internal genitalia, or on organs in close approximation to them. Various authors have cited the incidence of abortion in these cases as 4.5 per cent (Mussey and Crane), 15.8 per cent (Shallenberger), and 9.6 per cent (Casas). Several explanations have been offered for this high percentage of abortion, among which are: direct irritation of the uterus by operative manipulation (Varo, Greenhill, Shallenberger, Casas); excision of the true corpus luteum involved in an ovarian tumor or cyst; and performance of an operation at a date when the menstrual period would have appeared had the patient not been pregnant (Varo, Greenhill). Many authors have recommended, as a prophylactic measure, the use of morphine or one of its derivatives such as pantopon and dilaudid. More recently, Wilson, in writing on ovarian tumors in pregnancy, has suggested the use of progesterone as a therapeutic postoperative measure in those cases in which oöphorectomy includes the corpus luteum. This suggestion has also been voiced by Holmes.

Our study is a statistical survey of all operations excluding operative delivery, done on gravid women at the Michael Reese Hospital during a ten year period from January 1, 1928 to January 1, 1938. One hundred eight cases are reported, of which five aborted—an incidence of 4.66 per cent. This figure closely approximates that reported by Mussey and Crane, and is significantly less than the figures of Shallen-

berger and Cases. Of the 108 operations, ninety were intra-abdominal, and eighteen extra-abdominal. The intra-abdominal procedures were further divided into forty-eight genital, and forty-two extragenital operations.

Casas classifies genital operations as those on the genitalia whether external or internal; paragenital operations as those on organs in contiguity to the internal genitalia, such as the appendix; and extragenital operations as those on structures remote from the genitalia, such as the gall-bladder, kidney, stomach, and breast. We have preferred the simpler classification of extra-abdominal and intra-abdominal procedures, as we feel that such a division bears a closer relationship to the incidence of abortion, and is not apt to be confusing.

Table 1 records our gross figures, and shows the number and percentage of the procedures most frequently done, with the number of abortions consequent to them.

Of the thirty-two appendectomies, fourteen were done for chronic appendicitis and eighteen for acute appendicitis, this latter group being complicated by one perforation with local peritonitis. In this series, one abortion occurred on the thirteenth postoperative day, although cramps had begun as early as the fifth day.

Seventeen myomectomies were performed; the indication in six was red degeneration with marked symptoms of pain, tenderness, nausea, and vomiting, and in the remaining eleven, it was twisted pedunculated subserous fibroids. There was one abortion in this group, following removal of two degenerated interstitial fibroids situated in the lower uterine seg-

TABLE I

	Num- ber	Per- cent- age	Abor- tions
Total cases.....	108		
Intra-abdominal.....	90		
Appendectomies.....	32	29.0	1
Myomectomies.....	17	15.7	1
Oöphorectomies and ovarian resections.....	27	25.0	2
Miscellaneous.....	7	6.5	1*
Extra-abdominal.....	18		
Thyroidectomies.....	7	6.4	0
Breast tumors.....	4	3.7	0
Cervical polyps.....	5	4.6	0
Bartholin adenectomies....	5	4.6	0
Mastoidectomies.....	2	1.8	0
Trachelorrhaphies.....	1	.8	0

\* Cholecystectomy.

ment. Cramps and bleeding occurred on the fifth postoperative day.

In nine of the twenty-seven ovarian operations, no mention of the corpus luteum was made, but in five of the remaining eighteen cases, this structure was removed. In two of these five there were abortions, one on the second, and one on the eleventh day following the operation. Table II summarizes the significant clinical data.

TABLE II

Abor- tion	Age	Par- ity	Stage of Preg- nancy, Weeks	Operation	Indication	Onset Post- operatively, Day
1	34	2	8	Appendectomy	Mechanical appendix.	13th
2	31	2	8	Ovarian resec- tion	Cyst con- taining corpus lu- teum.	11th
3	26	2	8	Cholecystec- tomy	Cholecys- titis.	7th
4	29	2	8	Myomectomy and resection of corpus lu- teum	Bleeding corpus lu- teum. Twisted fi- broid.	2nd
5	29	2	12	Myomectomy	Degenerated fibroids.	5th

It is of interest to note that most (sixty-nine) of the operations were done in the first trimester of pregnancy, and that the

above five abortions occurred at this time. In addition, four of the five abortions resulted from surgery done eight weeks following the last menstrual period. The surgery in the fifth case of abortion was done twelve weeks following the last menstrual period. In other words, the operations were done close to the date upon which the patient would have menstruated had she not been pregnant. This is in keeping with the observations made by Varo and by Greenhill, although the exact relation of cause and effect has not been investigated.

In recent years, it has been shown by Falls, Lackner, and Krohn, that the corpus luteum hormone, progesterone, acts directly on the human puerperal uterus, inhibiting its motility. They have demonstrated its value in cases of habitual abortion. While it was formerly thought that removal of the corpus luteum very early in pregnancy would induce an interruption of the gestation due to cessation of hormonal activity, this has not proved to be the absolute rule, and it is now considered that progesterone may also be elaborated by the placenta, from the earliest stages of pregnancy (Ehrhardt, McGinty). Nevertheless, progesterone should have a place in the postoperative therapy of the pregnant woman. In only nine of the cases in this series, was the corpus luteum hormone used in the postoperative treatment. In none of these cases did an abortion occur, although the number of cases so treated is obviously too small to make any deductions. The remaining cases in which the five abortions did occur, were treated with morphine, pantopon and dilaudid, and the various barbiturates.

It has been shown by means of the intrauterine bag, that morphine increases, rather than decreases, uterine tonicity and motility. The same would probably be true of its derivatives; so that their efficacy in guarding against threatened abortion is questionable. While they may diminish body activity and pain sensation, they may also succeed in irritating an already excited



uterus. Certainly the barbiturates can have no specific effect on the pelvic viscera, being only soporific and hypnotic drugs. In progesterone, however, we have a medication which has been shown to act specifically on the uterus.

While it may be argued that the incidence of abortion in this or any other series is no greater than the normal expectancy of abortion in pregnancy (Mussey and Crane), or may be a result of the disease rather than the operation (Shallenberger), yet the fact does remain that improved surgical technique and anesthesia have diminished the frequency of abortion, and we can seek to lower it still further by the use of some preparation which inhibits uterine motility, and perhaps aids nidation. It is suggested that progesterone be used prophylactically in the postoperative therapy of gravid women in an attempt to decrease the consequent number of abortions.

#### CONCLUSIONS

1. Operative procedures on pregnant women, particularly in the early months of gestation, play a definite rôle in the incidence of abortion.

2. This incidence increases, as the manipulation involves the internal genitalia, especially the ovary bearing the corpus luteum.

3. It has been shown both experimentally and clinically that progesterone directly inhibits the motility of the human uterus.

4. No abortions occurred in a small series of cases in which progesterone was used postoperatively.

5. It is suggested that progesterone be used prophylactically in the postoperative therapy of pregnant women in an attempt to decrease the consequent number of abortions.

We thank the Schering Corporation for the proluton furnished for this study.

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# OSTEOPLASTIC REPAIR OF CRANIAL DEFECTS

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**M**ISPLACED decompressive operations, when the ventil is not placed beneath the temporal muscle, and indiscriminate removal of fragments of bone in the treatment of depressed fractures of the skull lead to troublesome cranial defects. Surgical treatment of an extensive cranial osteomyelitis, especially in the region of the frontal bones, as well as radical surgical procedures undertaken for the eradication of infection of the frontal sinuses also contribute to the frequency of deforming cranial defects. Clinical observations have shown that the pericranium may regenerate bone to fill in a defect in the child and the adolescent, while in the adult only rounding of the edges of the defect occurs through absorption.

The indications for repair of cranial defects vary with the site of the defect. Epilepsy, motor and sensory, including visual epileptic equivalents and psychic variants are seen when the defects are situated over the parietotemporal and occipital regions. Intense headache and dizziness, especially on exertion or with a low barometric pressure, are nearly constant symptoms when the defects are located over the vertex. Cosmetic reasons for repair are given in defects over the forehead; to the uninitiated a pulsating defect over the forehead or a sunken hollow that bulges with brain with a lowering of the head is a most disturbing sight.

Since the time when J. v. Mackren implanted a piece of bone from a dog into a cranial defect of a Russian boy (the graft was subsequently removed for religious reasons) numerous methods were proposed advocating various filling materials, inorganic and organic. The inorganic implants—aluminum and silver plates, celluloid and vulcanite—are used more because of tradition than for valid reasons. They act as

foreign bodies and are a constant source of irritation. They become encapsulated by inflammatory tissue and ultimately are displaced or moved about. They cause an inflammation of the underlying dura and lead to a pooling of cerebrospinal fluid between the thick dura and the brain. From time to time the skin covering the plate becomes congested, not unlike the skin overlying an encapsulated bullet.

Bone is the most frequently used organic substance. Heterogenous and homogenous bone transplants occupy a place midway between an inorganic object and an autogenous bone graft. They also behave as foreign bodies and present the additional disadvantage of a great tendency to absorption and disintegration. The contention that foreign bone transplants raise the calcium level in the blood and lead to better bone regeneration is pure speculation, to say the least.

Similar objections apply to transplants of autogenous bone boiled before use, as suggested by Naffziger.<sup>1</sup> When the bone is killed through boiling it cannot be considered a live autogenous graft; the roentgenograms of the implanted boiled bone flaps taken several months after the implantation, show extensive absorption of bone (Cases I and II of Naffziger). Besides, this boiling of the flap has a limited field of application, since it may be considered only in cases where a primary repair is the aim, and when the bone flap is affected by the extension of a neoplasm.

In evaluating various sources of autogenous grafts for the repair of cranial defects one must think, first, of the technical availability and adaptability of the graft and, second, of its ultimate fate years after the transplantation. The use of autogenous cranial transplants, consisting of the external table of the skull taken from an area

adjoining the defect, obviously is very limited. These grafts may be considered only in very small defects. The removal of a

linear fracture that extends through the base of the skull ossifies after a relatively brief period of time. This is explained

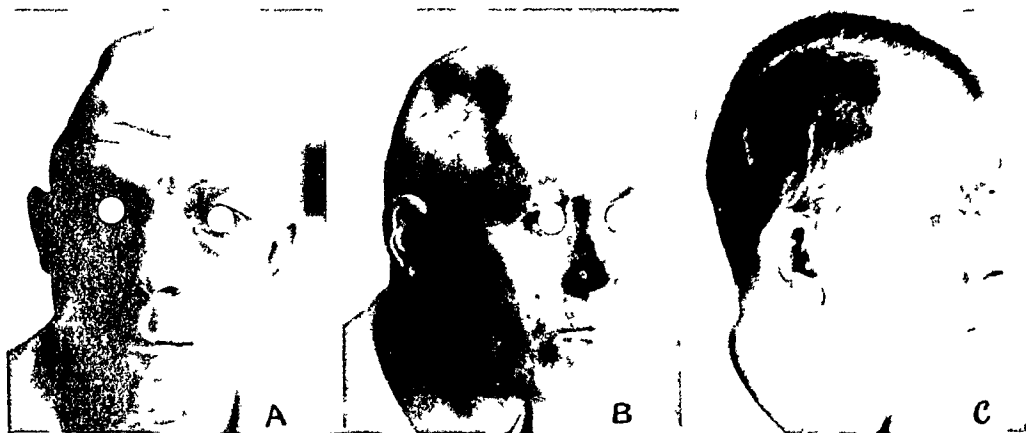


FIG. 1. A and B, showing large cranial defect resulting from poorly placed decompression done elsewhere. C, same patient, two weeks after osteoplastic repair.

larger disc of bone from the external table of the skull involves technical difficulties known to everyone who tried such a removal; even with the use of a thin bladed specially curved osteotome the flap will break repeatedly and lose its value as a rigid support.

A follow up of the grafts taken from the ilium, the scapula and the tibia—the most favored sites—has shown discouraging results. As a rule the transplants show marked absorption after which the defect largely reappears. Such results are to be expected when one recalls that even a primarily replaced cranial flap shows rarefaction years after the craniotomy. This is especially marked if the bone flap was stripped from the pericranium and its blood supply, as is often done in craniotomies to prevent a postoperative extradural hemorrhage. That this bone flap does not join the skull with regenerated bone but merely with fibrous tissue is well known.

This importance of the blood supply in the regeneration of the cranial bones is also seen in the ossification of linear fractures of the skull. While in children ossification of linear fractures takes place after months, in adults they become invisible only after many years. However, the portion of the

by the difference in the blood supply of the bones of the base of the skull from that of other cranial bones. In their embryologic development the bones of the base of the skull undergo the process of chondrification and are therefore much better supplied with blood, while the bones of the vault and sides of the skull are of a membranous formation. Our knowledge of the vascular system of the bones of the skull is limited to the venous circulation. When we know better the arterial blood supply of the skull we will understand why occasionally a cranial defect is filled with regenerated bone, while in most cases bone regeneration is absent.

While the overwhelming importance of the blood supply in the regeneration of bone in fractures of long bones is well established,<sup>2</sup> its importance in the regeneration of cranial bones is not sufficiently appreciated. It is futile to expect incorporation of a cranial implant as in the case of bone grafts of long bones with an abundant arterial blood supply and with the physiologic effect of the muscle tone on the underlying bone and its graft. In the skull the fate of the graft depends entirely upon the speed with which the implanted bone becomes vascularized in its new surroundings. The spongy transplant covered with

its original periosteum should therefore prove the most reliable graft.

The outer half of a split rib ideally

aspect of the rib is pushed away somewhat to insure against injury to the intercostal blood vessels and nerves and to the pleura.

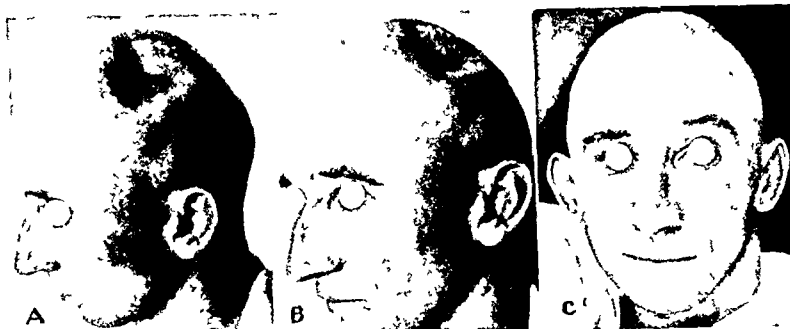


FIG. 2. A and B, cranial defect following surgical treatment elsewhere for depressed fracture of skull. C, same patient a few days after repair, showing perfect restitution of shape of skull by split ribs.

approaches this requirement. It is, besides, always available and easily adaptable. When taken from the rib in the middle axillary line the graft approaches the general convex contour of the skull. This makes bowing and bending of the graft unnecessary; because of the resiliency of the rib, bending gives only temporary results and the graft flattens out in the course of time by resuming its former shape. Remaining in intimate contact with the dura the graft causes no irritation and little thickening of it and hence fewer adhesions between the dura and the underlying brain.

While simple in principle, osteoplastic repair by means of the split rib graft demands meticulous care of detail in the securing of the graft, its transplantation and fixation in the new location. The sixth, seventh and eighth ribs on the right side are preferred. They are approached through a curved incision which is parallel to the costal arch and is bisected in its middle by the axillary line. The exposure of the rib differs from that used in thoracotomy and thoracoplasty; one must not injure the periosteum covering the external aspect of the rib. After the external intercostal muscles are cut away, one cuts through the periosteum along the upper and lower edges of the rib, marking the line of the split. The periosteum covering the mesial

Splitting the rib is a difficult step in the operation. In the past I used a thin narrow osteotome that was introduced into the end of the exposed rib with the bevel facing mesially; the rib was thus split by the advancing chisel. Occasionally the outer half of the rib broke and, although still attached to the main graft by the periosteum, it lost its value as a supporting implant. On one occasion the chisel slid out of the split and caused a tear of the pleura. Once the osteotome slid through the internal half of the rib cutting it crosswise. I found that one avoids these complications by using a curved, small, thin-bladed bone cutting forceps instead of a chisel.

In estimating the length of the sections of the ribs to be removed one usually errs on the short side. They should measure at least  $1\frac{1}{2}$  inches more than the longest diameter of the cranial defect. When more than one rib is required, as in large defects, one approaches the adjacent ribs through the same curved incision. The grafts are left in situ until their new bed is prepared.

The scalp overlying the cranial defect is turned up with due regard for the arterial blood supply, for the ultimate cosmetic result and for the subsequent draining off of the blood that gathers about the graft, to prevent a hematoma that will jeopardize the ultimate result. In a large defect two or more strips of rib are used for filling in the

defect by means of a suspension bridge framework.

Before excising the extensive scar tissue

underlying pericranium are sharply undermined and raised off the bone for a distance of 1 inch in length and  $\frac{3}{4}$  inch in width.

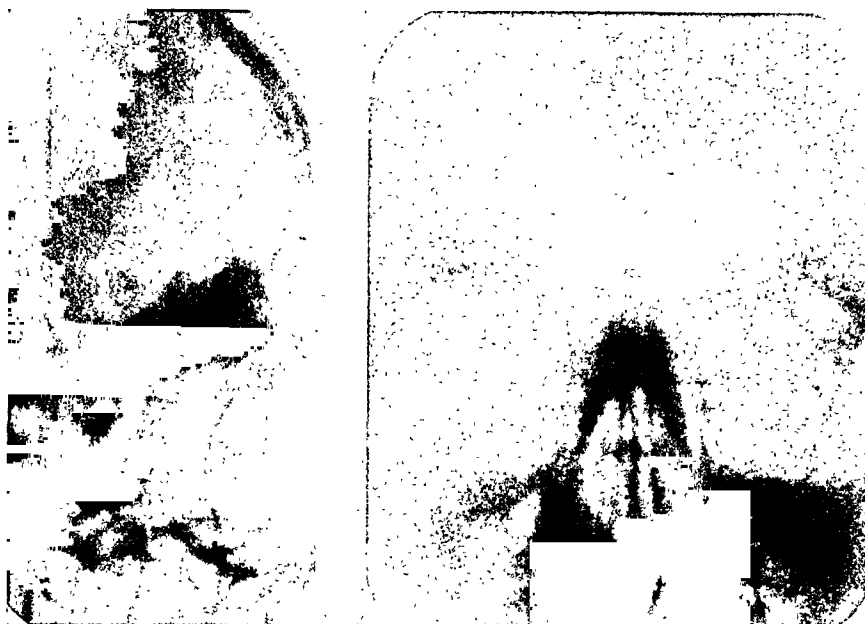


FIG. 3. Extensive frontal bone defect which resulted from surgical treatment elsewhere of an osteomyelitis after radical surgery of a frontal sinus infection.



FIG. 4. Same case as in Figure 3, three years after repair with split rib grafts. Shows bony union between the grafts and skull and satisfactory density of grafts.

for preparation of the bed for the grafts, one determines the future points of support of the grafts and marks them on the shelf of the cranium. At these points the dense scar covering the bony edge as well as the

The exposed bony edge is now beveled to form a bed for the ends of the ribs. It is rawed and roughened in such a manner as to secure the most intimate and close contact between the exposed diploe of the

cranium and the raw surface of the rib.

In very large defects the ends of the long grafts may be wedged and inserted into wedge-like buttresses at the ends of the gouged out bed in the skull. This will insure proper curving and bowing of the graft. In most cases, however, this tedious process may be omitted, since after the raised up periosteal flaps are turned down, tucked over the ends of the graft and sutured there the grafts are secure in their new situation.

No attempt is made to suture the dura to the graft. Great care is exercised in controlling all bleeding from the dura, the scar tissue about the cranial shelf and the turned up flap of the scalp. One avoids heavy catgut and any unabsorbable material. The scalp is then accurately sutured with a provision for drainage for twenty-four hours, to prevent an accumulation of serum that may interfere with an early adherence of the scalp and the dura to the surfaces of the graft. Snug bandaging and dependent posture for the first ten days will keep the dura in contact with the graft. The vascular scalp soon adheres to the costal periosteum, while the dura becomes attached to the spongy vascular raw surface of the graft. This promotes an early

establishment of a blood supply in the grafts, with an early bony union between the ends of the grafts and the raw bony shelf of the skull.

During the past ten years I have used this method of repair of a cranial defect in eighteen cases, in which the defects ranged between 2 and 5 inches in diameter. In five cases more than one operation was necessary before entirely satisfactory results were obtained. The final results in all cases were good; the defects were well filled and remained so years later.

At no time did any of the patients suffer later from the thoracic injury caused by the removal of the grafts. The ribs fully regenerated from the remaining half. Once a patient developed a pneumonia post-operatively on the side from which the grafts were taken. This may have been merely coincidental.

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# DEAD TEETH AND THE ANTRUM OF HIGHMORE

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THE Antrum of Highmore has long been a controversial field. One might aptly describe it as a sort of international settlement, in which the rhinologist, the surgeon dentist and the general surgeon feel that each has some particular qualification entitling him to its operative treatment.

My comments will deal with the first two. If antral suppuration is secondary to involvement of the upper air passages and sinuses, the rhinologist is indubitably the one best qualified to render an opinion as to what procedure should be followed.

Likewise, if antral involvement is dependent upon extension from an infected or suppurating tooth root the dental surgeon, in the careful surgical removal of the offending tooth, working in a dry field with novocaine anesthesia and adequate exposure, is in an excellent position to determine what additional operative treatment is indicated. It would appear that in some selected cases, a careful study of well taken roentgenograms and a consultation and collaboration of specialists might be of advantage, particularly to the patient requiring surgical treatment of his infection.

This might be emphasized, as I have operated upon several antral floors after nasal surgery had failed to cure chronic antral suppuration. The true etiology of the antral pathology, the dead teeth, had been ignored.

A study conducted with Dr. Frank Blaisdell at Stanford University has demonstrated conclusively the extension of inflammatory and septic reactions to parts distant from dead teeth.

I have evolved an operation for the surgical removal of dead teeth which has shown a high percentage of upper tooth roots involving the antral floor, giving evidence of the real etiology of many

chronic antral suppurations. Inflammatory proliferations are often direct extensions from dental pathology. Definite surgical dissection, working with direct vision and with hemorrhage under control, working only when the operative field is not obscured by blood, is essential. Injury and postoperative bacteremias from septic retention are avoided. Novocaine anesthesia and control of hemorrhage have been valuable adjuncts in obtaining this result.

Incomplete traumatizing surgery and extensive work in the presence of an acute infection are dangerous and may be the immediate cause of death. Osteomyelitis and death have followed antral surgery, particularly when an acutely inflamed sinus is curetted; bacteremia and death may follow the "pulling" of abscessed teeth, complicated by a diffuse infection. If the patient survives, postoperative fever and protracted convalescence are frequently observed. When the surrounding tissues are involved in an acute infection, incision, drainage and moist heat should be employed until the process becomes localized so that surgery may be undertaken with minimum risk to the patient.

Infective granulations must be completely removed, as retention in a sinus or a tooth socket means trouble. I find a rotated sponge is usually sufficiently effective in removing granulations from the sinus. If this method does not succeed, they must be dissected out carefully. Blindly curetting the antral cavity has resulted in injury to the lining membrane and the division or cutting of the alveolar nerves which lie between the antral membrane and the antral floor (not in the facial wall of the antrum). Numerous anatomic studies have confirmed this fact. It is to be borne in mind that the division of the alveolar nerves results in leaving the teeth

vital but insensitive. This frequently leads to loss of the teeth as there is no warning of the advance of tooth decay.

During the surgical removal of upper dead teeth pathologic perforations through the antral floor are frequently encountered. If necrosis is present the dead bone is removed. When the antral membrane is normal, thin and moving with respiration, it is not disturbed. A thick inflammatory membrane is rigid and should be incised so that the antral cavity may be examined for granulation tissue and polypi.

Removal of bone from below the antral membrane must be thorough as it is most important to leave the wound clean and free of any operative débris such as crumbs of bone and shreds of abscess wall; this will insure a smooth, uneventful repair, free from postoperative suppuration. Gauze packs are not allowed to remain in the wound, but are used only to control bleeding and to prevent bone chips from falling into the sinus. The gums are sutured with interrupted dermol which is removed on the fourth day. The alveolar process may be trimmed sufficiently to permit a flap to cover the antral opening. Uniformly good results have been obtained by this technique.

In my student days it was customary to irrigate a sinus for many months. Today I seldom find it necessary following surgery unless there is a postoperative rise in

temperature. Several of my patients developed influenza shortly after operation and the postoperative fever induced me to irrigate the sinus which was found clean.

If, however, irrigation should be indicated some days after operation a No. 9 American soft rubber catheter is introduced through the healing incision, the patient's head is lowered to between the knees and 2 liters of a warm  $\frac{1}{2}$  per cent solution of saline with boric acid added are run through by gravity. It may be advisable to do a preliminary shrinking of the nasal ostium. When the irrigation is finished the suction may be applied to the catheter end to dry the cavity completely.

#### SUMMARY

Metastasis with serious sequelae, from dental focal infection manifesting slight clinical symptoms, is an established fact.

In the acute diffuse infection, operative interference should be most conservative, limited to establishing free drainage until the process is localized. Moist heat applications have been found valuable in maintaining circulation of the blood, inflammation is defensive, when circulation becomes blocked the defense fails.

Careful surgical dissection under direct vision in a field unobscured by blood and the removal of all operative débris is essential to success.





# A SIMPLE METHOD FOR DETERMINING THE COAGULATION TIME OF THE BLOOD

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THE coagulation time of the blood is of tremendous importance in operative procedure. There are records of

mination of the coagulation time. The finger is cleansed and punctured in the usual manner. The first drop of blood is

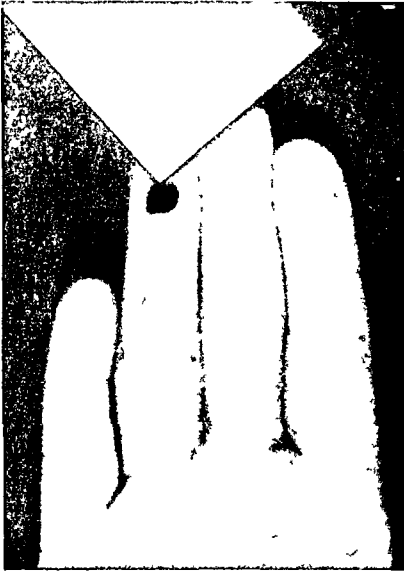


FIG. 1.

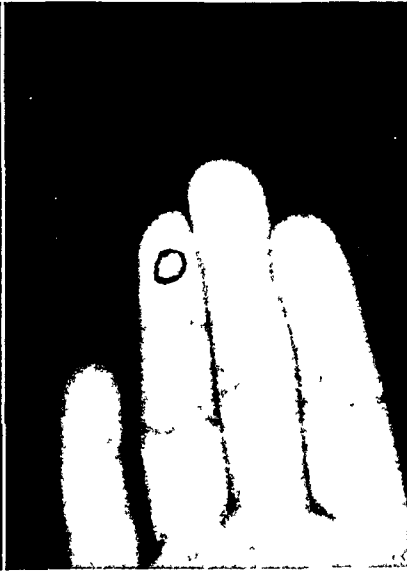


FIG. 2.

severe hemorrhage and even death due to the failure of the surgeon to protect the patient and himself.

There are many methods described for determining the coagulation time of the blood. All are more or less accurate, some require unusual skill and nearly all require apparatus or solutions, or both. In hospital practice, the surgeon depends largely upon the laboratory to make his tests, but minor operations are often done in the home or office and there the test must be made by the physician.

The following inexpensive and simple method may thus prove useful. It has been in use in the Wheatley-Provident Hospital for five years without the occurrence of a single fatality due to the inaccurate deter-

mination of the coagulation time. The second drop is allowed to remain for two minutes. Then the corner of a piece of absorbent paper is placed at the center and the blood from this part absorbed. (Fig. 1.) If coagulation has started, a ring (Fig. 2) will be seen at the periphery. The blood will coagulate there more quickly and remain adherent to the skin. If no ring is seen another drop is allowed to remain for four minutes and the procedure repeated. If still there is no ring, it is again repeated and the period increased until coagulation time is determined and safety of operative procedure established.

This method is sufficiently accurate, and is inexpensive and simple in operation.

# CASE REPORTS

## INTESTINAL OBSTRUCTION ASSOCIATED WITH ANOMALIES OF ROTATION AND FIXATION OF THE INTESTINE: REPORT OF A CASE

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**I**MPORTANT developmental changes which consist of an increase in length and in rotation and fixation are required to transform the primitive embryonic digestive tube into the adult digestive system. This paper is concerned with anomalies of fixation. However, without increases in length, rotation and fixation would not be necessary. Ideally, the process of fixation should take place only after increase in length and after the completion of rotation. Ideals are rarely attained during development. Actually, in practice, one encounters a great many variations of fixation of the intestine, but most of them are within what may be considered the limits of the normal. Anomalous fixation may be associated with failure of the first, second or third stages of intestinal rotation.<sup>1</sup> The lack of fixation associated with failure of the second or third stages of intestinal rotation or occurring in the presence of a normally rotated intestine may be the cause of intestinal obstruction. The intestinal obstruction is produced by an abnormal mobility which permits twisting of a segment or the whole intestinal mass. It is the object of this report to record an extraordinary instance of recurring intestinal obstruction which was due to volvulus of the intestinal mass. A failure of the second and third stages of intestinal rotation with lack of subsequent fixation was found at the time of surgical operation. (Fig: 1.)

### REPORT OF CASE

A man, aged 24 years, came to The Mayo Clinic complaining of intermittent attacks of abdominal cramps which had occurred since birth. During the first three months of life he had had great difficulty in retaining food and in gaining weight. The attending physician had seriously considered the possibility of congenital pyloric stenosis. After the patient had become three or four months of age he had begun to gain weight and strength and subsequently had attained normal development in spite of frequent attacks of abdominal pain. The attacks of abdominal pain always had occurred very suddenly. The pain had usually been referred to the lower part of the abdomen and had been intense and cramp-like. In all the attacks much borborygmus, abdominal distention and incessant vomiting had been present. The attacks had lasted from a few hours to two days or until he had begun to pass flatus. He had discovered early in life that an attack might be completely relieved by taking a "full enema" (about 2,000 c.c. of fluid). In the interim between attacks he had been comfortable, his appetite had been good and his bowel motions had been regular without the use of laxatives. His appendix had been removed during one of the attacks. At the time of the appendectomy it had been observed that the cecum was situated in the left half of the abdomen. A second operation had been performed for "adhesions."

Physical examination revealed that the patient was well developed but somewhat undernourished. He was 5 feet and 10 inches (177.8 cm.) in height and weighed 130 pounds (59 kg.).

Roentgenologic examination revealed that the colon was situated mainly on the left side of the abdomen. The cecum was in close approxi-

in the general region of the ligament of Treitz. The base of the mesenteric attachment extended a short way down the left side of the

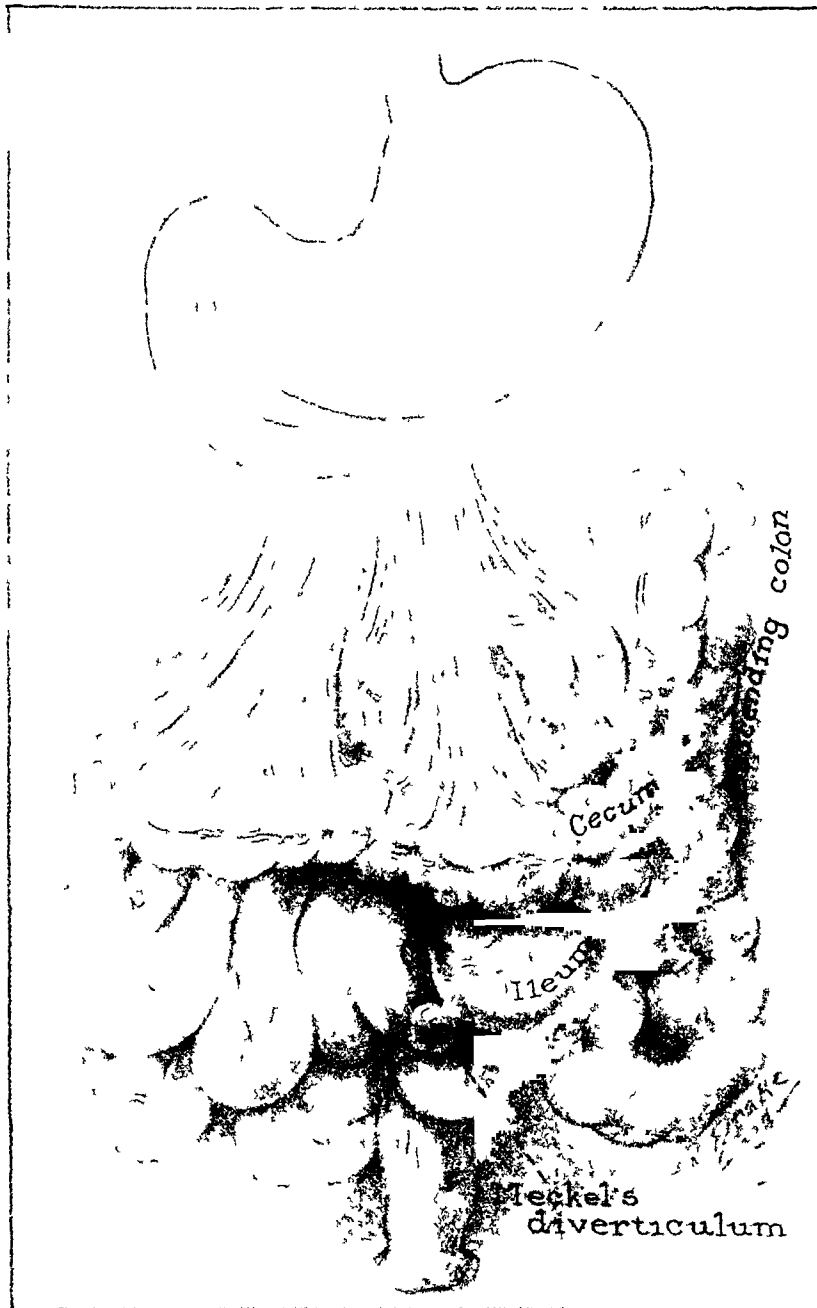


FIG 1. Schematic representation of intestine and colon as observed at time of surgical operation.

mation to the sigmoid colon and descending colon. Physical examination did not disclose any other abnormality.

At operation the total mass of the intestine was found suspended from a mesentery which was attached in the upper part of the abdomen

abdomen. The mesentery was thick and heavy and loops of the small intestine appeared to be rolled within its leaves. In some sections of the coiled and rolled mesentery, which contained loops of the small intestine, it was difficult to determine whether or not herniation of loops

of the small intestine had occurred. On retracting the mass of the intestine forward and out of the abdomen, it was observed that there were no posterior attachments of any part of the intestine to the right of the midline of the abdomen. The lack of attachment of the small intestine permitted its free rotation in an arc of 180 degrees in either a clockwise or counterclockwise direction. The cecum and sigmoid and the transverse segments of the colon were in close approximation and were loosely adherent to the small intestine. The cecum had not rotated; it appeared to be rolled posteriorly and was attached to the sigmoid segment of the colon and to a portion of the descending colon.

A Meckel's diverticulum was present about 15 inches (37.5 cm.) proximal to the cecum. The diverticulum was about 3 or 4 cm. in diameter and was shaped like the neck of a bottle. It was not removed because it had a wide non-obstructing neck and also because of the danger of prolonging the operation. The superior mesenteric vein was unusually large, about 2.5 cm. in diameter in its proximal segment, and was very prominent. The superior mesenteric artery also was prominent. The appendix had been removed at a previous operation.

The mesentery, which suspended the cecum, ascending and transverse segments of the colon, was freed from its attachment, which was situated in the region of the ligament of Treitz. The cecum and the ascending segment of the colon were carried across and fixed with silk sutures to the lateral and anterior portions of the abdominal wall in approximately their normal position. The omentum of the transverse colon was brought across to cover the small intestine.

During the first seven or eight days after the operation the patient was nauseated and unable to retain food. He then began to eat, and to gain weight and strength, and he seemed to be normal in every respect. A roentgenologic examination of the colon one month after operation revealed that the cecum and ascending colon had remained where they had been fixed at the time of the operation. On dismissal the patient said that he felt better than he had at any time.

#### COMMENT

The lack of fixation of the mesentery may be compatible with digestive health,

but when symptoms do occur they may be the result of volvulus, intussusception or occasionally, internal hernias. The commonest type of absence of fixation of the mesentery occurs when there is failure of the third stage of intestinal rotation. In cases in which there is a failure of the third stage of rotation, the cecum and proximal segment of the colon are left with varying degrees of mobility. It is necessary to emphasize that in our experience the so-called cecum mobile does not usually produce symptoms. We have found it a rather common occurrence.

Keyes recently reported two instances of failure of mesenteric fixation during the third stage of intestinal rotation in 148 cadavers. In neither had any known abdominal symptoms occurred during life.

Anomalous fixation of the mesentery which accompanies failure of the first or second stages of intestinal rotation and which is capable of producing serious symptoms may be divided into two groups: (1) the group in which there is failure of fixation of the small intestine, which makes possible the occurrence of volvulus of the entire mass of small intestine about the mesenteric pedicle,<sup>2</sup> such as occurred in the case reported in this paper; and (2) the group in which there are persistent congenital mesenteric bands which cause an intermittent and at times complete obstruction.<sup>4</sup> Gardner and Hart have reported two cases in which the anomaly belonged to the first group, and they reviewed the ninety-eight cases that had been reported in the literature. In eighty-eight of the ninety-eight recorded cases, volvulus resulted from twisting of the mass of the small intestine about the mesenteric pedicle. In the remaining ten cases the anomaly was the result of what these observers designated as "reverse rotation," which caused obstruction in the transverse colon. We have studied and recorded our experience in fifteen cases in which intermittent intestinal obstruction was caused by persistent congenital mesenteric bands accompanied by failure of the second stage of intestinal rotation.

In conclusion we wish to reiterate that anomalies of intestinal rotation and fixation of the mesentery are commonly observed. These anomalies are not usually productive of symptoms.

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THE anterior pituitary appears to be necessary for the absorption of glucose at a normal rate from the digestive tract. . . . The "diabetogenic" hormone of the anterior pituitary probably prevents the prodigal waste of important, but sometimes small, carbohydrate reserves which, for example, are maintained in spite of fasting.

From—"The Physiology and Pharmacology of the Pituitary Body," vol. II, by H. B. Van Dyke (University of Chicago Press).

# CYSTADENOMA OF THE PANCREAS

## REMOVAL THROUGH VERTICAL INCISION IN THE GASTROHEPATIC OMENTUM

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**C**YSTADENOMATA of the pancreas are of interest to the surgeon scientifically, because of their rarity and insufficiently studied pathology and they are of considerable practical importance to him so far as the technique for their successful removal is concerned. With this in mind, the case history of this patient is recorded, for further critical review.

Mrs. B. G., a woman of nervous constitution approaching the age of 44, for two years complained of a darting pain in the right lower abdominal quadrant, which radiated into the right groin. The pain was never severe. It was thought referable to the appendix by the patient but there were no characteristic seizures or findings. Occasionally there was also some pain in the right sacral region.

The patient readily became tired. Her eating habits and appetite were generally good, but she felt restrained in eating because of the pain in the right lower quadrant which followed. Her weight before operation was about 150 pounds.

There was habitual constipation, more pronounced in the previous one or two years. No complaints were referred to the urinary bladder. A hard mass in the abdomen had been noted a few days before.

The menses, originally normal, during several years past were prolonged to five or six days and small clots appeared. There was, however, no menstrual trailing. Beyond some bearable perimenstrual pain no pronounced molimina occurred. The last menstrual period had occurred two weeks previously at the estimated time.

She had had two normal deliveries, one at the age of 15, the other at 25. No abortions, curettements or operations were reported.

Twelve years before the patient had met with an automobile accident in which her

shoulder was bruised, but apparently no sequel remained except headache. She was subject to influenzal infection during the winter season, particularly two years before. There was a maternal history of thyroid disorder.

The mid-abdomen was prominent at the site of the mass, which was intra-abdominal, well circumscribed and apparently close to the abdominal wall. In relation to the umbilicus it could be outlined as follows:  $2\frac{1}{2}$  inches above, 3 inches to the left,  $2\frac{1}{2}$  inches to the right and  $1\frac{1}{2}$  inches below. (Fig. 1.) When it was held fixed under the palpating hand no traction appeared to be exerted by respiration. The mass gave the impression of limited mobility towards the left, but this proved to be erroneous when the abdominal wall was relaxed under anesthesia; its actual origin from the upper abdomen and fixed attachment posteriorly were then unmistakable. At the previous clinical examination attempts to shift the mass caused slight pain. Old circum-umbilical striae were noticed in the abdominal wall, but there was no change in the umbilicus, no infiltration, no enlarged veins.

The upper border of the liver was  $\frac{2}{3}$  inch below ensiform level and its lower border at "intersection point." The gall-bladder area was not tender, the lower pole of the right kidney not palpable, the epigastrium above the abdominal mass was flat and soft. The descending colon could be palpated readily and was impacted but not tender. The cecum was empty and there was no tenderness over the right beta point. No mass was palpable in the hypogastrium. Pelvic examination revealed nothing beyond a slight dextroversion of the uterus with a mild catarrhal endotrachelitis.

The urine was free of albumin and sugar.

The general impression was of a pedunculated myoma of the uterus. Carcinoma of the

transverse colon was considered at first, but under anesthesia the likely diagnosis rested between an omental mass and cyst of the pancreas.

verified by palpating through the foramen of Winslow with the left index finger. (Fig. 2.)

Instead of dividing the attachment of the

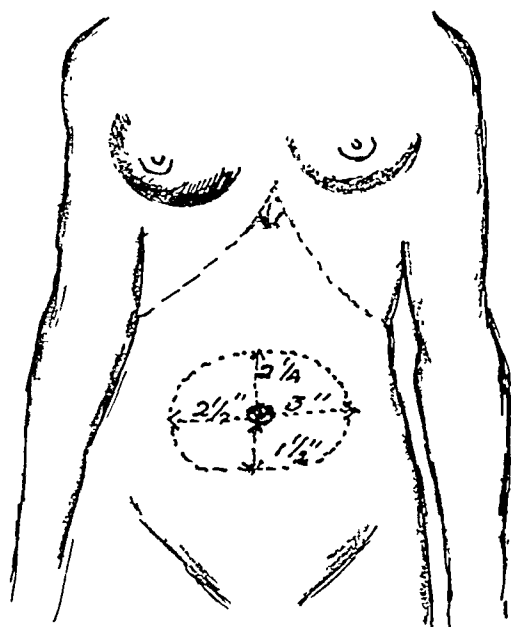


FIG. 1. Total extirpation of cystadenoma of the pancreas through the gastrohepatic route. Impression of tumor location and size by palpation and percussion before anesthesia.

Operation was done May 6, 1937 and lasted one hour forty-five minutes. Gas-oxygen-ether anesthesia was preceded by morphine sulfate gr.  $\frac{1}{4}$  and atropine sulfate gr.  $\frac{1}{150}$ . Near the end of the operation intravenous infusion of physiologic saline solution was administered: 400 c.c. were given in the operating room and an additional 200 c.c. in bed.

The real origin of the abdominal tumor then became more evident; the mass appeared fixed and had shifted towards the upper abdomen. The incision was placed slightly extramedian, being carried to the left of the umbilicus, and after exploration through the smaller incision, it was extended upward to the ensiform notch.

The stomach, pylorus and first part of the duodenum appeared normal. The liver margin was high. The table rack was raised at the level of the upper abdomen to put the patient into the gall-bladder posture. The transverse colon showed no lesions. There was no omental tumor or mass.

When the stomach was drawn downward, a bluish surface with grape-like contour could be seen through the gastrohepatic omentum. Connection of the mass with the pancreas was

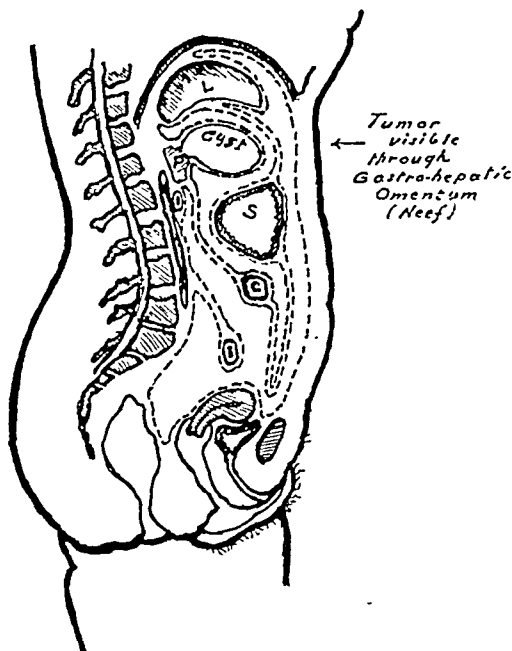


FIG. 2. Complete removal of cystadenoma through vertical incision in the gastrohepatic omentum. No drainage. Primary healing.

lesser omentum to the lesser curvature of the stomach, we made a vertical slit in the gastrohepatic omentum to gain access to the lesser sac and the space behind the stomach. Through this route the tumor was liberated and removed by stripping and dissection, with careful adherence to the surface of the mass and palpation for larger vessels to be secured. As the tumor was gradually lifted from the surface of the pancreas posteriorly and towards the left, a vein the size of a goosequill and a pulsating artery of similar caliber were identified. The vein was ligated and a small portion of pancreatic tissue removed with the growth. Some time was consumed in obtaining thorough hemostasis and a dry tumor bed. (Fig. 3.) No drain was used. The slit in the gastrohepatic ligament was not closed by suture, but coapted well when the stomach was allowed to return to its normal site. The cystic tumor was removed intact with the exception of one small loculus which was punctured during the procedure and from which spurted a clear fluid, 4 to 6 inches high from a pin point opening. (Fig. 4.)

During and after operation the pulse rate reached a maximum of 140, but its quality

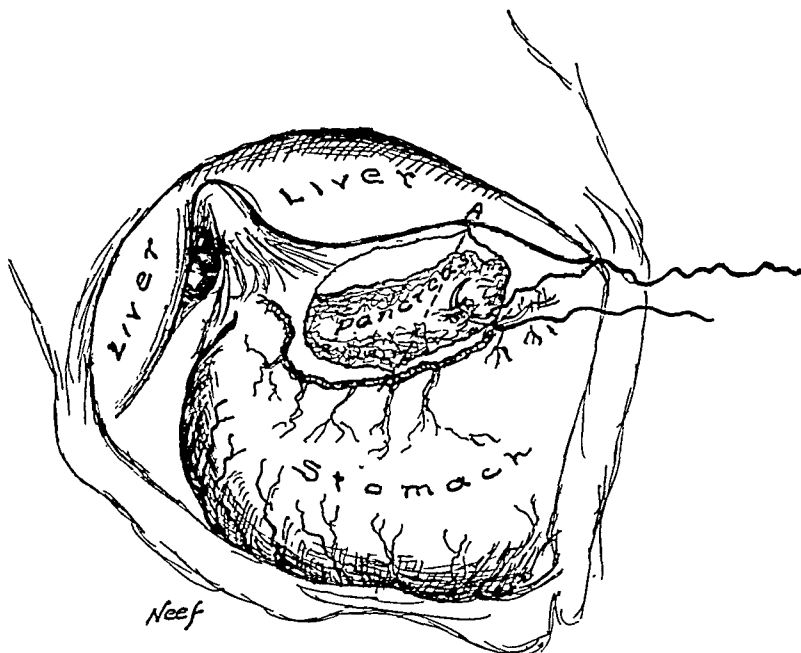


FIG. 3. Pedicle stitch inserted after removal of tumor through vertical slit in lesser omentum.



FIG. 4. Reconstructed diagram of mass. Tumor measurements  $9 \times 9 \times 6$  cm. Individual cysts from 0.4 to 2.4 cm. in size. A, strip of pancreas. B, site of origin near tail of pancreas.



remained relatively good until the final step in tumor removal. Then it became poorer but was promptly restored as the warm saline took

attached to the surface. Section revealed a multilocular cystic structure throughout. The individual cysts were smooth-walled and con-



FIG. 5.



FIG. 6.

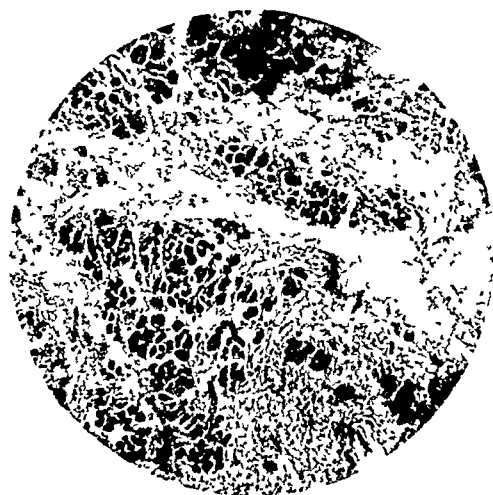


FIG. 7.



FIG. 8.

FIGS. 5 TO 8. Photomicrographs of cystadenoma of pancreas.

effect. At the end of operation the pulse rate was 140; the pulse quality was good, eyelids tonic, pupils narrow, color slightly flushed, breathing quiet. Within an hour after the return to bed the pulse rate dropped to 116 and remained satisfactory.

The mass measured 9 by 9 by 6 cm., and its surface was studded with multiple thin-walled cystic nodular projections ranging in size from 0.4 to 2.4 cm. in diameter. A small piece of pinkish and finely lobulated pancreatic tissue approximately 2 by 1 by 0.6 cm. was firmly

tained serous fluid brownish-yellow or, more often, dark brown in color. (Fig. 4.)

Microscopic examination showed congeries of cysts of various sizes lined with one or multiple layers of small undifferentiated cells. The outlines of some of these were poorly delineated, while others were sharply defined, the latter being cuboidal or polyhedral in shape. The nuclei were small, spheroidal and rather chromatic, the cytoplasm apparently non-granular and usually clear. The latter was evidently free of lipoid material since no fat was

demonstrable by the Scharlach R stain. There were no definite papillary ingrowths, though in localized areas the cells were heaped up in the

tumor, though there was a quantity of pancreatic tissue attached to the outer surface. The growth was well vascularized and in some regions

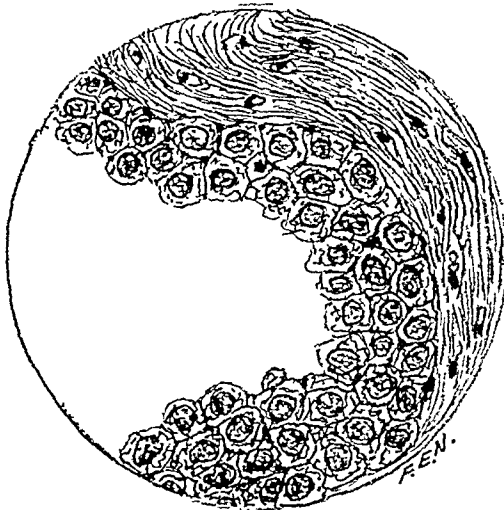


FIG. 9. Multiple cell layer in wall of cyst. (X 333.)



FIG. 10. Cysts lined with a single layer of epithelium.

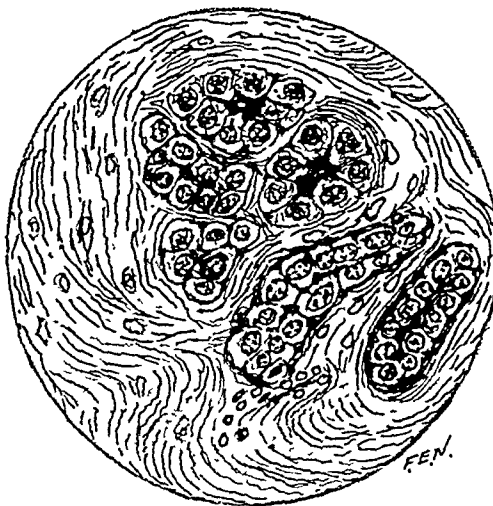


FIG. 11. Section of pancreas. (X 333.)

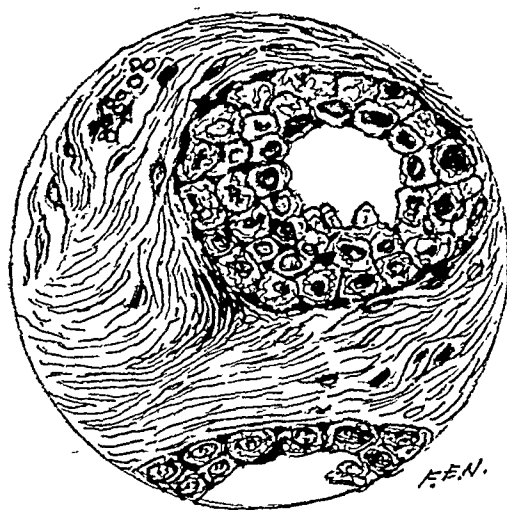


FIG. 12. Section of a small cyst under high power.

form of blunt or slender processes which projected into the cyst cavities. These cavities were generally empty, but some contained serum, erythrocytes and a few desquamated or inflammatory cells. The supporting septa differed in thickness and consisted of connective tissue of varying density and cellularity, loose and edematous in some places, dense or hyaline in others. In some of the septa there were a few glandular spaces lined with cells similar to those lining the cysts and there were also small nests of cells reminiscent of islet cells. *Neither pancreatic acini nor ducts could be identified in the*

showed scattered hemorrhages together with an irregular inflammatory infiltration, the inflammatory cells consisting chiefly of small round cells. (Figs. 5-14.)

A review of the various slides obtained from this tumor indicated that about 85 per cent of the cyst spaces were lined with a single layer of epithelium; in about 3 per cent the epithelium was from two to five cells deep, making due allowance for the plane of section, and in approximately 1 per cent small localized papillae were observed. This behavior is quite

analogous to that observed in multilocular cysts of the ovary.

*Postoperative Course.* Hypodermoclysis with

of general abdominal and epigastric distress. The temperature rose to 102°F., the pulse varying from 108 to 116, of good quality. No

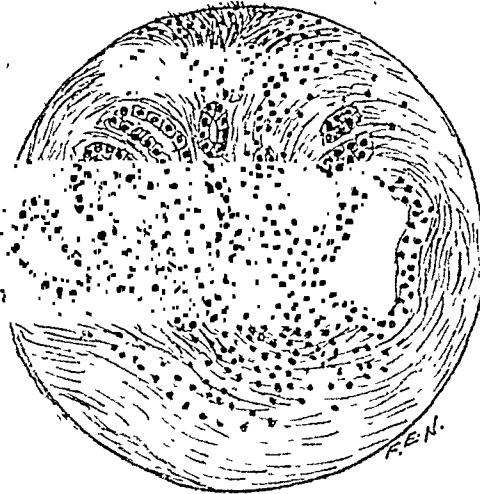


FIG. 13. Intercalated tubules and round-cell infiltration in connective tissue stroma.

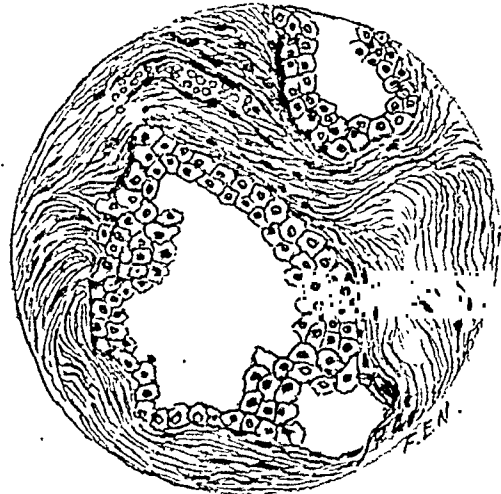


FIG. 14. Cyst sections. (X 125.)

saline was instituted towards evening of the day of operation and 1,000 c.c. fluid were given in this way. Within eighteen hours after operation the maximum rectal temperature reached 103.4°F., with respiration 18, pulse 120 soft, fair in volume, and regular. The chief complaint was thirst and this was met by starting the rectal drip with plain water at the rate of 16 drops per minute continuously, except in the morning and evening from 6 to 8 o'clock. Morphine sulfate gr.  $\frac{1}{4}$  with atropine sulfate gr.  $\frac{1}{150}$  were administered as needed.

No liquid by mouth was tolerated for forty-eight hours after operation. The period of thirst was followed by one of heartburn on the third day. The patient was still thirsty and quite irritable. Bed exercises for the extremities were encouraged and the patient was tilted to the right or to the left side. The heartburn was finally overcome by feeding thin cream of wheat with milk, cream soups and lime water made palatable with milk and given in 2 ounce doses.

On the fourth day gas distress and gas pain were relieved by means of the siphon enema with plain water and without the help of pituitrin. On the fifth day the gas pain waned and the patient was put on a convalescent's diet.

The sixth day following operation towards evening the patient was greatly upset because

heartburn was present. The next morning, that is six and a half days postoperative, the menses appeared. The first dressing was done at this time and all the stitches were removed. The incision line was dry and there was no infiltration or local disturbance.

On the eighth day postoperative the temperature reached its maximum of 102.2°F. The cytologic and chemical blood examination at this juncture showed the following:

#### Blood Cytology

Hemoglobin.....	68 per cent (10.6 Gm.)
R.B.C.....	4,980,000
W.B.C.....	29,800
Differential { Polys.....	84 per cent (22 per cent immature cells)
{ Lymph.....	14 per cent
{ Mono.....	2 per cent

#### Blood Chemistry

Urea N.....	9.3
Creatinine.....	0.5
Uric acid.....	2.5
Sugar.....	97.
CO <sub>2</sub> combining power.....	55.7 volumes per cent

The urine contained no acetone, diacetic acid or sugar.

Thereafter the temperature dropped gradually and was again normal on the thirteenth day after operation. Seventeen days after operation the blood cytology was as follows:

Hemoglobin	62 per cent (9 Gm.—standard 15.5 Gm.)
R.B.C.	3,100,000
W.B.C.	5,800
Differ- ential	{ Polys 64 per cent (12 per cent immature)
	{ Lymph 30 per cent
	{ Mono 4 per cent
	{ Eos 2 per cent

The patient was allowed out of bed and went home two days later, after a total hospital stay of nineteen days.

#### CLINICAL RETROSPECT

1. There is an apparent disparity with reference to location and mobility as ascertained before anesthesia and during it. As the diagram of the office findings in the recumbent posture showed, the mass presented itself in the umbilical region and conveyed the impression that it moved with respiration. Under anesthesia, on the other hand, it was most prominent in the epigastric area and appeared to be more fixed; nevertheless positive differentiation between an omental mass and pancreatic cyst could not be made before operation. On exploration, however, a bluish mass nearly 4 inches (about 9 cm.) in diameter could be seen between the liver and lesser curvature of the stomach, pushing the gastrohepatic omentum before it. That it was a tumor arising from the pancreas was easy to verify by introducing the left index finger into the foramen of Winslow.

2. In this approach, deviating from the usual, the lesser omentum was incised vertically to avoid division of blood vessels supplying the lesser curvature. Through this opening the multilocular tumor together with a small strip of pancreas was extirpated.

3. Drainage was omitted. This would seem to lessen postoperative intra-abdominal irritation due to the presence of a foreign body in the territory of the solar plexus. It also allows the divided gastrohepatic omentum to coapt perfectly and heal without interference. Besides obtaining a minimal degree of intra-abdominal cicatrization and adhesion, the union of the abdominal wall itself is interrupted at no

point so that there remains no postoperative sinus when the sutures are removed at the first dressing—in this instance six and a half days after operation.

One year after operation the patient's average gross weight was about 150 pounds. She had lost weight before undergoing operation. The weight one month after operation was 133 pounds; in a further three weeks 134½; six months postoperative 144½, and 140½ on revision one year after operation. At this time she excluded sweets from her diet.

Some symptoms remained which were referable to occasional hyperthyroidism with palpitation on the heart. The patient mentioned that she still had some abdominal pain in the right side, which, however, was indefinite and absent for two weeks at a time. Her appetite was very good, food no longer upset her digestive function, there was no discomfort after eating. She also stated that she had not been constipated for nine months after her operation, slept well, and experienced no pain in the region of the scar.

#### SUMMARY

It is noteworthy that the history of this patient contained very little that was suggestive of her real disorder.

Initially even pelvic origin of the tumor was considered, because it projected itself largely in the umbilical area as the diagrams which were made at this time indicate. A neoplasm of the transverse colon or an omental mass might also be found in this location. Not until the patient was under anesthesia was its attachment in the upper abdomen clearly defined making a cyst of the pancreas likely.

The gastrohepatic omentum was found stretched over the presenting tumor and was incised vertically instead of according to the usual technique. This opening, with slight lateral traction, afforded sufficient working room. Vertical incision had the advantage of being in itself bloodless and obviated the necessity of severing the vascular attachment of the gastrohepatic

omentum to the lesser curvature of the stomach.

As was expected the removal of a small strip of pancreas at the vascular base of the tumor had no noticeable effect on the patient's blood chemistry.

Another deviation from the usual procedure was the avoidance of all drainage of the tumor bed. The reflex upset caused during convalescence by drains lodged in this region, as well as the formation of adhesions and delay in the complete closure of the abdominal wound may be factors of some importance; and, where there is reason to believe that the hemostasis is secure, the bed is dry and the wound is clean such drainage appears unnecessary.

A review of the literature reveals that a number of conditions which are not true neoplasms have been classified as pancreatic cysts, and, in other instances the pathology was too meager to establish that the tumor was a true cystadenoma. The growth which is described here is histologically a benign neoplasm and belongs to the group of true cystadenomata.

The number of cystadenomata of the pancreas recorded as successfully removed is comparatively limited. In this patient it was an advantage that the cystic tumor had its vascular attachment to the tapering body of the pancreas. If it had arisen nearer the head of the gland, the simpler technique might not have been applicable.

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\* With few exceptions the references to the literature are restricted to cystadenoma of the pancreas. Of the group of reported cases assembled in this list by Dr. S. A. Ritter only a very small number was subjected to radical surgical treatment with successful extirpation of the pancreatic growth.

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# SACROCOCCYGEAL TERATOMATA IN THE NEWBORN

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**S**ACROCOCCYGEAL tumors are composed of many different types of tissue; there is found in them fetal nerve tissue with ganglion cells, remains of the central canal, choroid plexus, epidermis, smooth and striated muscle, bronchial segments, intestines, liver, suprarenals, fibrous connective tissue, mucosa, cartilage and bone. Congenital postsacral teratomas usually contain a preponderance of nerve tissue, so that rests of the neural layer have been considered as the source of these tumors.

The tumor is usually a benign growth. The degree of cell differentiation is important in the consideration of malignancy, as the more the cells approach the adult type, as in the formation of glands and of organs, the less is the possibility of malignancy. Gross clinical evidence of adult tissue is indicated by muscle twitchings or peristalsis in the tumor or the demonstration of bone tissue. Teratomas found anterior to the sacrum and posterior to the rectum do become malignant.

Stewart, Alter and Craig reported a tumor which was anterior to the sacrum, in a boy of 2 years and 11 months, which metastasized to the liver, lungs and regional lymph nodes. Parin reported six cases undergoing malignant degeneration with metastases, and deVeer and Browder reported one case. Renner and Goodsit also reported a case of malignant teratoma anterior to the sacrum following the removal of a postsacral teratoma.

These tumors vary greatly in size. They may be anterior to the sacrum and entirely intrapelvic, or they may present a huge external mass as large as the infant's head externally and dorsal to the sacrum and coccyx. They are found most frequently in females. Galbert estimates that they occur once in 34,582 births; Ewing states that

one-third of the fetuses with sacrococcygeal teratoid tumors are born dead, while 90 per cent of the others die soon after birth.

These tumors contain both cystic and solid elements, and may increase in size very rapidly in the first months of life. This rapid increase in size, according to Hansmann and Berne, is not to be taken as a sign of malignancy but as a growth of the tumor paralleling the infant's growth.

The following is a report of teratoma in a newborn, with complete removal of the tumor on the fourth day of life, in which recovery followed.

The baby was admitted to the Springfield City Hospital one hour after birth. The mother, aged 20, was a primipara, in whose family twins were common. She had noticed during her pregnancy a large mass in the upper right zone of the abdomen. Labor was slow; after the head and shoulders were delivered all further progress ceased and traction proved futile. On palpation an obstructing mass was discovered. The infant was finally delivered by introducing the hand along the posterior wall of the vagina over the baby's buttocks and flexing the baby over the mother's abdomen.

The infant was normal except for a solid and cystic tumor mass attached to the sacrum, measuring about 15 cm. in diameter. This mass extended laterally under the gluteal muscles almost to the trochanters. The skin over the mass was greatly thinned; the capillaries in the skin were injected in the upper portion of the tumor and this area was dark red in color. No pulsations or change in size were noted when the child's position was changed. The tumor extended farther on the right side than on the left, and over this area there were constant muscular twitchings. The lower extremities were normal and reacted to sensory stimuli.

The blood count was normal: red cells 2,700,000; hemoglobin 58; leucocytes 7,000 and polymorphonuclears 32 per cent.



X-ray examination with a catheter in the rectum showed no communication between the rectum and the tumor, although the mass

Several different masses, containing nodes of similar structure were observed. Many smaller noduli and many cysts contained water-clear



FIG. 1. Section showing some of tissues in bronchi. Note cartilage, pseudostratified ciliated "respiratory" epithelium and mucus glands. ( $\times 250$ .)

appeared to be adherent to the posterior rectal wall. Many small dense masses were visualized within the tumor.

Due to the fact that the skin over the vertex of the mass showed signs of breaking down, operation was performed on the fourth day of life. An oval incision was made about the base of the tumor. The skin was easily separated from many dark colored cysts which made up the upper part of the mass. The lower solid portion of the tumor was dissected from the rectum and, with some fibers of the gluteus maximus muscles, was removed. There was very little bleeding, but the child was shocked. Transfusion was done on the table. The wound healed without infection.

The specimen weighed 502 gm. and after partial removal of fluid from the tumor, a decrease of weight of 182 gm. was noticed. Three different tumors were present, the largest the size of a large grapefruit of distinct nodular structure. The covering skin measured 12 by 4 cm. The skin was closely adherent to the tumor and was not movable over the mass.



FIG. 2. Area of teratoma showing mixture of types of epithelium and connective tissue. Small island of hyalin cartilage, stratified ciliated columnar epithelium, tall columnar epithelium containing mucus and small mucous glands resembling those seen in bronchi. There are numerous smooth muscle fibers in a loose connective tissue stroma. There are numerous dilated lymph spaces. ( $\times 75$ .)

and yellowish-white turbid fluids. After removal of the fluid the tumors presented a honeycomb appearance. Other nodes of different gross appearance showed cartilage, connective tissue and a substance which resembled brain tissue.

Microscopic examination showed several different types of tissue. Bronchial structures, such as cartilage, pseudostratified ciliated "respiratory" epithelium, and mucus glands, were noted; brain, adipose and fibrous connective tissues with striated muscle fibers were also found. The predominant material present was brain tissue with smooth muscle fibers running through it. Brain surrounded by heavy deposits of melanin was found in some sections. One area showed choroid plexus with columnar epithelium lining a small cyst. Many mixed types of epithelium and connective tissue were also present. Rindfleisch has aptly called these tumors a *bistologic pot-pourri*.

According to H. W. Hundling a number of developmental errors account for these tumors. "It is in this area that the caudal

termination of the primitive streak should most accurately attain its evolution and involution, the neurenteric canal develop

After the third month the vertebral column is longer than the cord and the caudal end of the cord is drawn upward.

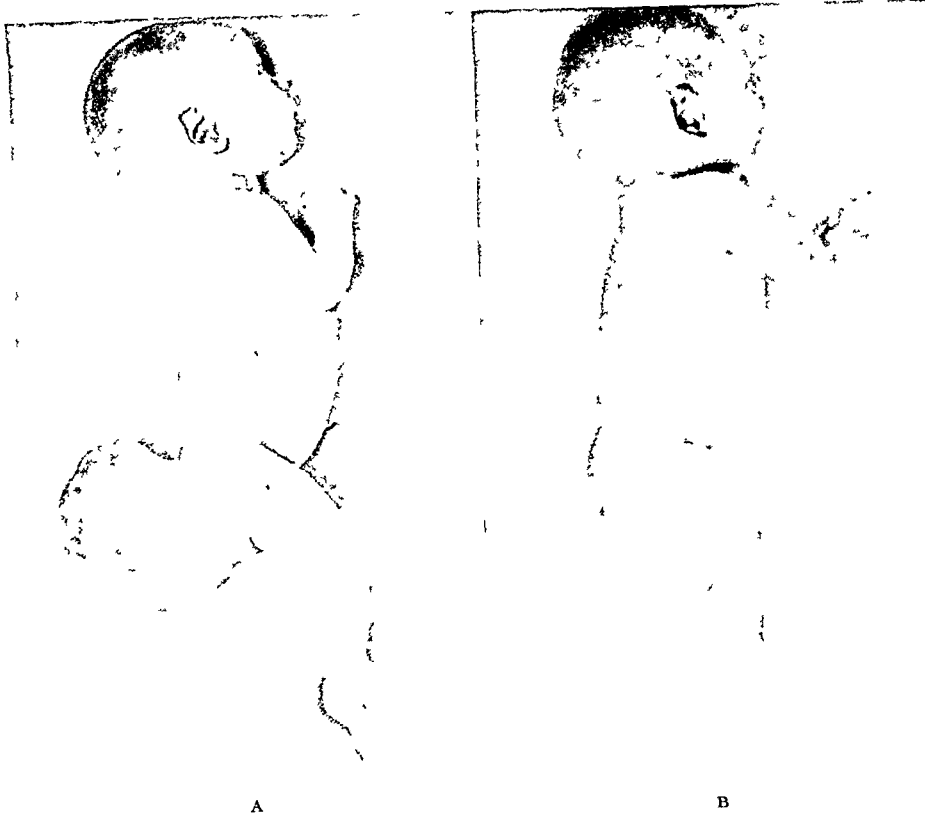


FIG. 3. Photographs of subject.

and disappear, the anus complete the intestinal tube, the posterior fissure properly close, the coccyx and sacrum develop, and the inferior extremities adapt themselves to the trunk. During the third month of fetal life the neural tube extends to the end of the vertebral canal and into the tail bud. The spinal canal, developing faster than the soft parts, draws along the neural tube adherent to it. The coccygeal portion of the neural tube is bent into a loop of which the deeply situated limb is attached to the posterior surface of the coccyx, while the superficial one assumes a more dorsal position. This deep limb disappears at four months and the superficial one continues to develop. The spinal chorda and the mesoderm develop at the same rate. The tail bud is reduced with a reduction of the mesoderm. The spinal cord is now longer than the vertebral column."

"While the endoderm is forming the caudal intestine, the dorsal canal and dorsal cord, the mesoderm, the connective tissue, blood vessels, vertebra and muscles, and the ectoderm is forming the primitive streak, the medullary tube and its vestiges, there is a continuation between the central canal of the spinal cord and the primitive alimentary canal around the caudal extremity of the notocord known as the neurenteric canal. When the proctodeum or primitive anus, invaginates to form part of the cloacal chamber, it meets the gut anterior and above where the neurenteric canal opens into it, hence there is for a time a segment of intestine behind the anus termed the postanal gut."

From this complicated fetal development and recession of the different tissues many theories have arisen as to the origin of sacrococcygeal tumors. Their early

development is fairly definite proof of their relationship to embryologic processes. Hansmann and Berne think the embryo-

Teratomata may possibly arise from parthenogenetically developing sex cells. This modification of the old bigeminal



FIG. 4. Area of choroid plexus. Note single layer of cuboidal cells and preponderance of nervous tissue elements. ( $\times 375$ .)

logic structures occurring in this region, in the hindgut, proctodeal membrane, and in the neurenteric canal, are sufficient to account for the varying types of tissue in these tumors. According to Ewing, although some of the tumors may with considerable certainty be referred to a single embryonal structure, the majority are more complex and probably involve more than one of these embryonal remnants and some additional anomalies of development.

Tumors of the lumbosacral region, according to Middledorff, Ristchl and Nasse, are due to proliferation of the remains of the neurenteric canal, hindgut and medullary canal in association with ectodermal and mesodermal inclusions. Middledorff was the first to ascribe their origin to the postanal gut. Grosser, Lewis and McMurrick also think the neurenteric canal, the postanal gut or the neural canal is the source of these tumors.



FIG. 5. Cartilage, smooth muscle, transitional epithelium and tall columnar epithelium containing mucin. Brain tissue is again seen in the stroma. ( $\times 100$ .)

theory has been given much support by Bosaeus in his work on the origin of ovarian embryomata.

MacCallum believes that teratomatous tumors in the sacrococcygeal region, which approach the complexity of twin inclusions, are best explained as originating from an isolated blastomere with varying potentialities. He states: "A teratoma resulting from parthenogenetic development of a sex cell would be of the nature of an offspring, while one derived from an isolated blastomere would be of the same generation as the host, a twin." The histogenesis of these tumors is usually considered to be independent development of a blastomere during segmentation of the ovum or the development of a misplaced ovum. In view of the constant position of these tumors it is difficult to accept this explanation.

Ziegler states: "If a teratoma can be found to contain very diverse tissue formation which, at least in part, may be

identified as representing rudiments of organs which, however, are superfluous for the individual in whom they are found, we may consider such a tumor as a heterochthonous teratoma, or a bigerminal implantation that is a rudimentary twin. On the other hand, if the teratoma contains only diverse tissues and cysts whose production does not necessarily imply the existence of a second division, the tumor may be looked upon as an autochthonous teratoma or a nongerminal implantation."

The bigerminal implantation was held by Virchow, Ahlfeld and others, while Bonny and Bland-Sutton held to the theory of dichotomy of the fetal axis, or the suppressed fetus theory. Adami thought a growth of totipotential cells at the inferior growing point was the cause of teratomata, and Tourneux claimed their cause was a persistence the medullary coccygeal vestige.

Theory after theory has thus been presented as to the causation of these tumors and no one has been universally accepted. It is the consensus of opinion that due to the complicated embryologic development of the lower axis of the body, tumors of various types of tissue are possible, but it is impossible to attribute the development of sacrococcygeal teratomas to any one fetal structure.

The treatment is surgical removal. How soon after birth the tumor should be removed depends on the condition of the skin, whether the growth is extra- or intrapelvic, and the rate of growth. These tumors may ulcerate through the skin by pressure necrosis and become infected; if they are intrapelvic they may, by their rapid growth, cause intestinal obstruction.

## CONCLUSIONS

1. A case is presented of sacrococcygeal teratoma in a newborn, with operation and recovery four days after birth.
2. Many kinds of tissue, including brain, cartilage, muscle, bronchial, and glandular tissue were found in this tumor.
3. Theories for the causation of these tumors have been reviewed.
4. The treatment recommended is immediate surgical intervention.

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# A CASE OF PERITONITIS COMPLICATED BY PROGRESSIVE MUSCULAR DYSTROPHY\*

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THE symptomatology in this case of generalized peritonitis complicated by progressive muscular dystrophy is of particular interest in that the atrophy which involved both recti and other abdominal muscles, altered the clinical picture usually present in peritonitis. The points of interest were the absence of spasticity and rigidity which was accounted for at the time of operation and subsequent necropsy. This also explained the presence of the marked distention as a prominent symptom found at the time of examination.

C. B., male, a farm hand, aged 31, was admitted to the neurological ward in 1930. The following history was obtained at that time: At the age of 12, the patient had noticed wasting of the thenar muscles; the muscles of the arms and legs were normal. At the age of 17, he noticed marked wasting of the muscles of the upper extremities. Somewhat later, wasting started in the leg muscles and there was difficulty in walking. After 1924, a gradual but progressive development of muscular weakness occurred.

The patient was a 31 year old white male with wasted arm, scapular, trunk and thigh muscles. He went through complicated routine movements in getting into the sitting posture. His pupils reacted to light and accommodation; the fundi were negative. Conjunctival and corneal reflexes were present, as was the pharyngeal. Deep reflexes were absent in the upper extremities. The abdominals were present, *more active on the right*. The cremasteric reflex was present and active, the patellar absent, and the Achilles present. Other pathologic reflexes were not noted. No sensory disturbances were elicited. There was considerable atrophy of all the extremities, more marked in the upper. The characteristic winged scapulae and characteristic postures while

attempting to rise were observed. Faradic responses were all present and speech was unaffected. The feet presented slight pes cavus.

The family history was not contributory as the patient did not remember his parents.

A juvenile type of progressive muscular dystrophy was diagnosed.

On April 24, 1938, the patient was again seen. He had had diffuse abdominal pain with distention and eructations of two days' duration. The onset had occurred three days prior to admission, about one and one-half hours following a meal. The following morning he took some milk of magnesia. This was followed by a good bowel movement and some relief of pain. Later in the day, and especially the following day, the abdominal pain and general distress became unbearable and the patient consented to be admitted to the surgical ward.

The patient, now 39, appeared acutely ill, with flushed and apprehensive face. The tongue was coated and dry. There was evident marked wasting of all the muscles of the extremities, chest and trunk. In order to allay pain, the patient lay quietly. His temperature was 103, pulse 95, respirations 20, blood pressure 115/65. Heart and lungs appeared normal. There was marked rebound tenderness and distention of the abdomen and also *complete absence of spasticity and rigidity*. The presence of peritonitis was apparent and immediate laparotomy was advised. However, the patient refused operation.

The following morning the tongue was heavily coated and moist. The abdomen revealed a lack of rigidity throughout (*muscular dystrophy*); tenderness was generalized and rebound tenderness marked. The urine was negative. The white count 14,600, polymorphonuclear leucocytes 83 per cent, lymphocytes 15 per cent, monocytes 2 per cent. Red cells numbered 3,200,000. Temperature was 102.4, pulse 100, respirations 22.

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The clinical picture was one of generalized peritonitis, distorted because of the presence of muscular dystrophy and the mentality of the patient. His apprehension bordered almost on panic and he had the mentality of a 10 year old. However, he finally gave his consent for an operation.

Under gas-oxygen-ether anesthesia a lower right rectus incision was made. All abdominal muscles showed fibrosis and atrophy. The rectus muscles were represented by a fibromuscular band. Free seropurulent fluid exuded under pressure from the general peritoneal cavity. The appendix was found ruptured and gangrenous, retrocecal, and bound down by a mass of adhesions. It was fragile and broke off in handling. The appendiceal stump was carbolyzed and purse-stringed. The terminal ileum appeared markedly inflamed and the ileocecal valve almost occluded. A cecostomy tube was purse-stringed through the anterior band of the cecum and the tube fed through the ileocecal valve into the ileum for a distance of about 8 inches. The cecum was sutured to parietal peritoneum and a Penrose drain was placed in the retrocecal fossa and pelvis.

The postoperative diagnosis was: ruptured appendix, with ileitis and general peritonitis.

On the first and second days after operation the patient's general condition was apparently good; distention was absent and the temperature was 101 degrees. On the third day marked distention appeared, with vomiting and abdominal tenderness. The cecostomy tube drained satisfactorily. Treatment for the peritonitis consisted of Wangensteen suction, sedation, and parenteral fluids. The general condition was slightly improved on the fourth day and continued fair for the following days. On the seventh day, the general condition appeared excellent—there was only slight distention and the cecostomy tube was draining. The eighth day showed a turn for the worse; greenish-black vomitus appeared, with moderate distention and a fecal discharge around the cecostomy tube. On the tenth day, the cecostomy tube sloughed out; profuse drainage of fecal matter occurred through the cecostomy wound and through the lower angle of the incisional wound. Marked distention and tenderness, especially on the right side of the abdomen, was noticed. From the eleventh to the eighteenth day, the temperature ranged from 101 to 103 degrees. The general condition

showed a steady downward course. Consolidation in the left chest appeared on the eighteenth day, and on the nineteenth day the temperature was 105, the skin cold, clammy and cyanotic, the pulse thread-like, and labored respiration. Death followed.

*Autopsy.* The body, that of a young man about 39 years of age, was poorly developed and poorly nourished. There was a considerable amount of post-mortem hypostasis, particularly over the back, neck and abdomen. *There was no rigor mortis in any of the extremities.* Bedsores were found over the sacral region and over the right thigh. The body was delicate stature, with only a slight amount of hair; the hair over the pubes assumed female distribution.

The chest was flattened and its muscles markedly diminished in size and volume; the left anterior chest wall showed no pectoral muscle and the intercostals were atrophied. On the right side there remained a small amount of abdominal and chest muscle. Both lungs showed numerous adhesions to the chest wall as well as to the diaphragm. An extensive pneumonic process was present throughout the left lung with irregular yellowish patches suggestive of pyemic foci. The right lung showed only congestion, some pneumonic infiltration and pulmonary edema. A necrotic area containing liquefied dark material, obviously localized lung gangrene, had developed in the posterior axillary portion of the left lung.

The abdominal wound from below the umbilicus to the level of the inferior spine of the ilium had raw, ununited edges, its surface being gangrenous and covered with greenish exudate. The abdominal muscles were practically absent, so that the skin was the prominent layer of the abdominal wall. A large amount of pus was present in the peritoneal cavity, bounded by the right diaphragm and omentum. The small intestines were dilated, the loops of the ileum adherent to each other as well as to the abdominal wall and the right side of the abdomen. In the region of the cecum, loops of small intestines were matted together, encircling a pocket of pus; these loops were also adherent to the pelvic wall. One portion of ileum was necrotic. The cecum and ascending colon were involved in a suppurative process, the colon adherent to the duodenum, gall-bladder and liver, while the cecum was entirely gangrenous and adherent to the abdominal wall. A large amount of pus, particularly

inspissated, was found in the region of the cecum. The abdominal wall covering the region was entirely necrotic. The distal half of the transverse and descending colon were contracted and apparently not markedly involved in the gangrenous process. A few adhesions were found between the upper sigmoid and pelvic wall, while a large pocket of pus was present in the left pelvic fossa. On the posterior abdominal wall there were numerous greenish masses.

The spleen, enlarged to twice normal size, was of soft consistency, hemorrhagic and bilobar, weighing 200 Gm. The left adrenal was decreased in size and appeared hemorrhagic on section. The right adrenal was somewhat decreased in size but otherwise showed no marked abnormalities. The pancreas was of usual size and, on section, appeared degenerated. The liver was larger than normal, its diaphragmatic surface showing an area about 10 cm. in diameter covered with yellow exudate, due to the accumulation of pus between the diaphragm and the dome of the liver. The gall-bladder was distended and covered by omental adhesions

due to the infectious process in the peritoneum. It contained thick bile but no stones.

The muscles of the extremities appeared markedly atrophic, particularly those of the upper extremities. The muscles of the hand were all decreased in volume.

The pathological diagnosis was: (1) muscular dystrophy (facioscapulohumeral type); (2) acute gangrenous appendicitis; (3) acute peritonitis; (4) sepsis; (5) acute inflammation of ileum and cecum; (6) lobular pneumonia and pyemic abscesses of lung; (7) acute parenchymatous degeneration of internal organs.

#### SUMMARY

The absence of abdominal musculature due to progressive muscular dystrophy disguised the symptomatology in this case of ruptured appendicitis with peritonitis. The lack of spasticity and rigidity was accounted for by the absence of the abdominal musculature. The possibilities of symptoms being masked in other neurological diseases complicated by the acute abdomen, must be kept in mind.



# ANGIOBLASTIC SARCOMA OF LIP\*

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CARCINOMA of the lip is of relatively frequent occurrence, but sarcoma is a rare form of malignancy to affect this organ. Tibor De Cholnoky,<sup>1</sup> in 1934, reported four cases of sarcoma of the lip and from the literature gleaned only twenty cases described, quoted or mentioned, the records of all but five of which were incomplete from either a clinical or a pathologic standpoint. Most of the patients were senescent, although one was a child 1½ years old. The stated duration of the lesion varied from a few weeks to several months. There was a history of trauma in only one case.

The lesions varied from a few millimeters to several centimeters in diameter, were reddish-blue or deep red in color, bled easily and had a smooth or more or less lobulated surface which proceeded to ulceration. Histologically the lesions were classified as spindle-cell, round-cell and mixed-cell sarcomas, lymphangiosarcoma, neurogenic sarcoma and melanosarcoma; spindle-cell types predominated. Metastases occurred in two cases.

Wide surgical excision of the primary lesion was the predominant mode of treatment. Irradiation was less effective. Two patients died within a few months from generalized sarcomatosis. Cholnoky's cases were symptom-free six, six and eight months, and four years, respectively, after operation. In three of these four cases dissection of regional lymph nodes accompanied wide local excision of the lesion, while the lesion occurring on the upper lip was removed by electro-coagulation.

Cholnoky stated that there were two cases of sarcoma of the lip reported from the Göttingen Pathologic Institute among

1,248 cases of sarcoma of all anatomic locations. Sarcoma of the lip was not mentioned in Simmons's<sup>2</sup> series of 177 cases of sarcoma of the soft parts, in the review of tumors of connective tissue by Geschickter and Lewis<sup>3</sup> or in that of tumors of blood vessels by Geschickter and Keasbey.<sup>4</sup> Freilich and Coe,<sup>5</sup> in 1936, reported a case of angiosarcoma of the scapula and found twenty-nine cases of angiosarcoma recorded in the literature since 1918; reports of twenty-six of these were available; one of the twenty-six, that of M. Prati (1931) was primary in the lip; two were primary in the tongue. In the York Hospital from 1932 to 1935 there were 9,110 adult admissions (1,740 of these were maternity cases); in this period there was only one case of sarcoma of the lip—the one herein reported.

## CASE REPORT

T. F., male, white, 53 years of age, was admitted June 16, 1935 with the complaint of a bleeding and painful lower lip. In April, he had been struck on the lower lip by a small stone while at work. The lip became swollen and a "blood blister" formed. The area did not heal but gradually enlarged and began to slough and bleed slightly. About four weeks before admission to the hospital the growth became painful to move, and sometimes it bled profusely. The family history was irrelevant. He was not a pipe smoker, nor had he ever been troubled with any ulceration, crack or sore on the lip prior to the trauma.

The physical examination revealed nothing remarkable, except the lesion of the lip. This covered an area about the size of a quarter dollar on the vermilion border of the lower lip, to the left of the midline, and protruded outward for at least ½ inch. It was of a lobulated

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fungoid type, with a comparatively constricted base. The surface was fairly smooth, darker red at various places, and oozed blood. The super-

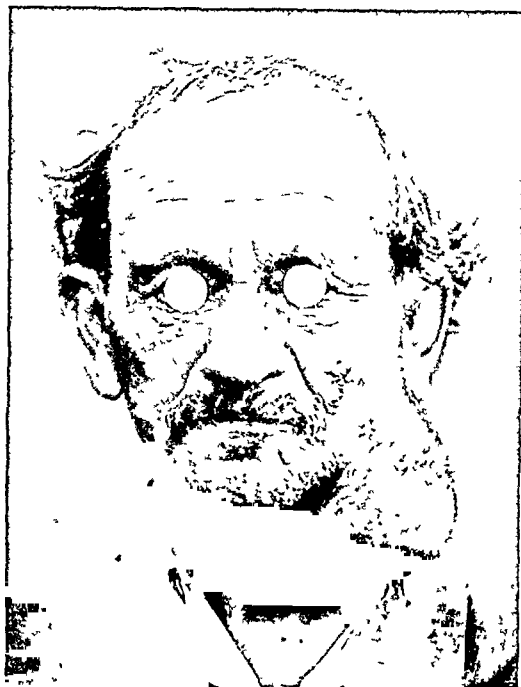


FIG. 1. Appearance of patient after resection of lip. A large metastatic tumor of the neck, of approximately four months' duration, is seen. No recurrence at operative site.

ficial tissues were somewhat necrotic and sloughing. The regional lymph nodes were not palpably involved. There was a secondary anemia of moderate degree. The Kahn test was negative.

Removal of the growth and cheiloplasty were performed on June 17, 1935. A V-shaped incision was made in the lower lip, allowing approximately 2 cm. of lip tissue on either side of the growth. The left arm of the V began close to the left commissure, meeting the right arm of the V well over the mental region. These incisions sloped slightly from the skin toward the mucous membrane of the buccal surface, thereby giving greater thickness and insuring better healing and less thinning of the scar. Blair's lip clamps were applied on either side in order to control bleeding without excessive vessel ligation. The left commissure was then incised horizontally and a Bernard triangle was dissected from the upper lip, following the nasolabial crease and utilizing the mucous membrane of the back of the triangle for the vermilion border. In performing the cheilo-

plasty the skin sutures were placed first and superficially, but on the gingival side the sutures were placed deeply and made to include the fibers of the orbicularis oris, as in the repair of an anterior alveolar cleft. Oral hygiene was instituted before the operation and continued after the operation, including a sterile diet for the first forty-eight hours.

The tissue removed at operation was received in the laboratory in a solution of formaldehyde. It consisted of a wedge-shaped portion of lip, 2.5 by 2.0 by 1.5 cm., to the mucocutaneous margin of which was attached a pedunculated, fungoid, reddish-brown mass, not unlike a mushroom in size and shape, 2.5 cm. in diameter and 1.5 cm. thick. The outer surface was lobulated and ulcerated, largely covered with coagulated blood. Except for this coagulated blood the cut surface revealed a relatively homogeneous, solid, gray structure, poorly demarcated from the underlying tissues of the lip, at the ill-defined junction with which hemorrhage into the tissue was seen. The diameter of this junction was 1 cm., constituting a potential pedicle without appreciable length, the periphery of the mass overhanging and resting on the cutaneous and mucous surfaces of the lip.

Microscopically a rather densely cellular neoplasm composed of a matrix of pleomorphic cells supporting numerous vascular channels was seen. These vascular channels in sections were devoid of contents and for the most part did not have a definite wall, except that imparted by the bordering pleomorphic cells. These cells were fusiform, round, ovoid and polyhedral in shape. Those irregularly of fusiform shape predominated; some had a narrow elongated process; an occasional cell of stellate shape was seen. Cytoplasm and cellular processes everywhere were acidophilic. Nuclear variation in size, shape and chromatin content was a conspicuous feature. Many nuclei were strikingly hyperchromatic. The nuclei of the more differentiated cells were ovoid in shape, moderately pale and had an evenly distributed finely divided chromatin network. Nucleoli nowhere were prominent. There were a large number of mitotic figures.

The diffuse arrangement of the neoplastic cells, their lack of any definite grouping, the predominance of those irregularly of fusiform shape with nuclei having obscure nucleoli were features characteristic of sarcoma and not

characteristic of carcinoma. The inclusion of numerous apparently vascular channels, lined by neoplastic cells, indicated an origin from

rhage were noted on May 21, 1936. He was very weak and markedly emaciated. Death occurred on June 5, 1936.

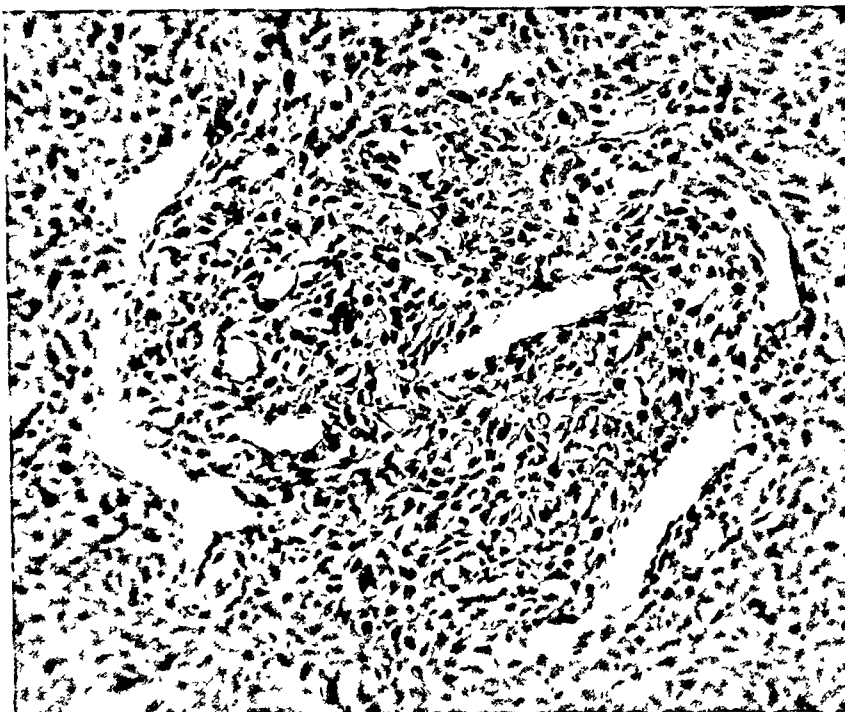


FIG. 2. Low power photomicrograph of tumor of lip. The diffuse heterogeneous arrangement of the neoplastic cells, among which ramify vascular channels, is seen.

vessel walls. The neoplasm was interpreted to represent the malignant counterpart of benign angioma, of which the lip constitutes a common site of occurrence, in other words, *angioblastic sarcoma*. The structure in this case did not permit of differentiation between lymphatic and hemic vascular origin.

Histologically the degree of malignancy was relatively high, 3 to 4, if all sarcomata are classified into four groups for purposes of histologic prognosis, based chiefly on cellularity and anaplasia. According to criteria and terminology used by one of us<sup>6</sup> the malignancy index would be 4.

*Course after Operation.* The surgical wound healed and the patient was discharged from the hospital on June 26, 1935. The following October, he noticed a tumor of the left side of the neck. It was of subcutaneous location and increased in size gradually but rapidly. The patient was readmitted to the hospital on May 17, 1936 at which time a semisolid mass the size of a large grapefruit protruded from the left side of the neck, also overlying the mandible. Ulceration, sloughing and hemor-

rhage were noted on May 21, 1936. He was very weak and markedly emaciated. Death occurred on June 5, 1936.

*Autopsy.* Extreme degrees of emaciation and dehydration were noted at autopsy. Most of the bones of the skeleton were clearly outlined.

A soft subcutaneous mass, 15 by 12 by 6 cm., extended from the left mastoid process to the midline of the neck anteriorly, and from the temple to a point 2 cm. above the clavicle. The lower portion, somewhat pendulous, overhung the clavicle. The convexity of the mass consisted of a nearly circular ulcerated crater, 11 cm. in diameter, which was filled with soft, spongy, gray and red tissue, in part semifluid, from which blood dropped freely on manipulation. The fingers could be introduced readily into crevices between the soft masses occupying the crater to a depth of 5 cm.

Dissection of the neck disclosed an invasive strand of neoplastic tissue, soft and grayish-white, resembling cerebral cortex, about 5 mm.

in diameter, extending from the mass along fascial planes downward, disappearing beneath the manubrium and clavicle. It apparently ended there as no intrathoracic extension could

## COMMENT

The terminology employed in the classification of neoplasms varies considerably,

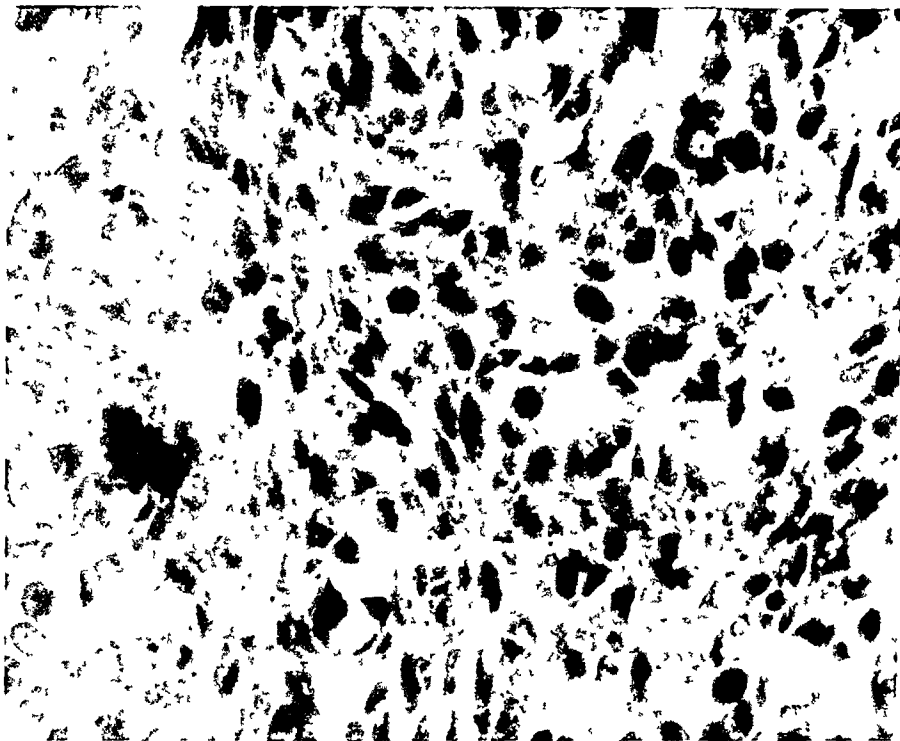


FIG. 3. High power photomicrograph of the tumor of the lip. Pleomorphism, mitosis, and the relationship of the cells to vascular channels are more clearly depicted.

be traced. Tumor thrombi filled and distended the lumen of the external jugular vein to a diameter of 15 mm., but were not found in the subclavian and innominate veins or in the vena cava. The mandible was intact to palpation. No intraoral extension of the mass could be found nor any distortion or ulceration of the mucous membrane.

A wedge-shaped area of gray and hemorrhagic infarction, 2 cm. in diameter, was found at the base of the lower lobe of the right lung. A white tumor thrombus filled the axial blood vessel leading to the area. Except for bronchopneumonia of the lower lobe of the left lung, the autopsy revealed nothing further of note. No metastases other than that of the right lung could be found.

Microscopic studies revealed that the neoplastic tissue occupying the external jugular vein and the pulmonary arterial branch had a sarcomatous structure similar to that of the tumor removed from the lower lip in June, 1935.

rendering comparisons difficult. Sometimes bases of histogenesis and of morphology irrespective of histogenesis are used interchangeably in the same series, with the result that two or more instances of a given type of tumor are recorded under different designations, giving the impression that different types of neoplasms are referred to. For example, a "spindle-cell" sarcoma may well be a "neurogenic" sarcoma as well as one of fascial, vascular or osseous origin. One would believe angiosarcoma or angioblastic sarcoma to be a form rarely assumed by sarcoma of the lip, as judged by case reports. Yet Cases II and III of Chlcnoky's paper, classified as spindle-cell sarcomas, and perhaps Case I, reported as round-cell sarcoma, have angioblastic features, as portrayed by the photomicrographs. Since angiomas scarcely are rare

among the benign lesions of the lip, one might expect that the malignant counterpart of these lesions would be encountered occasionally.

The resistance of this lesion to irradiation is manifest in that the tumor of the neck continued to grow rapidly during the course of radiotherapy and to the end of life, as if stimulated by it.

#### SUMMARY

A case of sarcoma of the lower lip is reported in a man 53 years old. The lesion was removed surgically two months after it was first noticed. Cervical metastasis appeared four months later, without recurrence at the operative site. In the course of the ensuing eight months this metastatic mass attained a diameter of 15 cm., and the

overlying skin sloughed away, leaving a wide, deep, bleeding crater. Neoplastic thrombosis of the left external jugular vein and pulmonary metastases were found at autopsy. Death occurred fourteen months after the primary lesion was noticed and eight months after metastasis became manifest. Deep Roentgenray therapy was without apparent effect on the growth of the metastatic cervical mass.

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# BILIARY PERITONITIS WITHOUT PERFORATION AS A CLINICAL ENTITY

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A CASE of peritonitis of biliary origin without a perforation either of the gall-bladder or ducts seems worth recording, with a brief review of the literature.

## CASE REPORT

The patient, a male of 38, reported on June 28, 1937, that for one month he had had irregular attacks of abdominal pain with no localization, nausea, vomiting or jaundice. His bowels were normal and the distress was not related to his meals.

On June 27, at 8 P.M. he had a sudden severe attack of excruciating pain in the mid-epigastrium. The severity of the pain, the shock, and the absence of other symptoms simulated coronary occlusion. One-half grain of morphine was administered, but gave no relief. After the hypodermic of morphine the patient vomited once. Eighteen hours after onset the pain radiated to the right lower quadrant and the patient was admitted to the hospital. He was then acutely ill, with severe epigastric distress and pain in the right lower quadrant. The abdomen was tender throughout with rebound tenderness most acute high in the right lower quadrant. There was no jaundice.

The temperature (rectal) was 101.4, the pulse 85, respirations 22, and blood pressure 140/90. The red blood cells numbered 5,050,000; hemoglobin was 100 per cent. The white blood cells were 12,700, with 78 per cent polys, 2 per cent eosinophiles, 11 per cent small lymphocytes and 9 per cent monocytes. Nuclear index was 3.2. Urine examination was negative; but the specimen was not examined for bile.

Acute appendicitis with peritonitis was diagnosed.

At operation 8½ ounces of dark brown fluid were found throughout the abdomen, but especially in the right lower quadrant, with greenish fibrin on the bowel. This suggested

a ruptured ulcer, but palpation revealed an enlarged tense gall-bladder not surrounded by adhesions or omentum. The gall-bladder was dark, cylindrical and tense. There were no stones palpable nor was there any evidence of perforation. The cystic and common ducts were palpable, enlarged and indurated. The stomach and the duodenum were normal. The cystic duct was isolated and clamped near the common duct; it was found to be completely occluded with mushy material. Aspiration of the common duct produced dark bile; it was opened, irrigated with a catheter to the duodenum, and drained. The gall-bladder and appendix were removed.

Clinical and pathologic examination of gall-bladder and cystic duct revealed no perforation.

The gall-bladder measured 11 by 2.5 cm. and was covered with fibrinous purulent exudate. It was filled with a mushy, greenish, soft mass, with innumerable mulberry-like calculi. The mucous membrane was irregularly marked by areas of atrophic mucosa. The wall varied from 1 to 6 or 7 mm. and had the appearance of a chronic inflammatory process with acute inflammation. The appendix was grossly normal.

Microscopic examination of the gall-bladder showed a markedly thickened wall, with hyperemia and infiltration with polymorphonuclear leucocytes—a definite active infection probably grafted on an old process.

The patient made an uneventful recovery and was discharged on the eighteenth day after operation. Slight drainage persisted.

Clairmont and von Haberer,<sup>4</sup> Buchanan,<sup>3</sup> Tormey,<sup>11</sup> and Stenson<sup>10</sup> have reported similar cases and in each of these the clinician considered the fluid as bile. No perforation was demonstrated, although in no case has the fluid been examined chemically or bacteriologically and only in autopsied cases has it been possible to examine the entire biliary tract for perforation.

The appearance of the fluid is different from that of biliary ascitic fluid found in many other conditions. The absence of perforation seems substantiated in that most ruptured gall-bladders are localized and walled off. Wesson and Montgomery,<sup>13</sup> in sixteen cases of gall-bladder rupture, did not find generalized peritonitis in any at the time of operation.

Theories offered regarding the origin of the fluid include: filtration through the gall-bladder and bile ducts due to some undemonstrable pathologic change in their walls;<sup>4</sup> action of pancreatic juice making the wall permeable;<sup>2</sup> microscopic perforation with rupture of gall-bladder subsequently healed; rupture of intrahepatic bile canal; postperitoneal rupture of perforation of the common or hepatic duct.

Mentzer,<sup>8</sup> from a report of traumatic cases, concludes that sterile bile has not been proved to be a cause of death. He feels that death is due to pyogenic rather than chemical peritonitis when it occurs.

Harkins<sup>6</sup> produced bile peritonitis experimentally with ligation of the common duct and defundation of the gall-bladder. Two injected dogs died; three treated by aspiration also died. Harkins concludes that rapid death in bile peritonitis is due to shock, blood pressure fall and decrease in blood volume and increase in concentration.

Andrews and Henry<sup>1</sup> suggest that bacteria may play but a secondary rôle in disease of the gall-bladder and that other possible factors—mechanical, vascular, toxic and chemical—deserve more careful study.

Ravdin, Morrison and Smith<sup>9</sup> attempt to prove that bile ascitic fluid is relatively innocuous because of low bile salt content. Whole bile injected into the dog produces death. They feel, therefore, that in bile

peritonitis there must be an opening with direct communication with the biliary passages. Bacteria cannot be demonstrated as easily, even in pathologic gall-bladders, as they can be in normal intestine.<sup>1,7,12</sup>

### CONCLUSIONS

1. Biliary peritonitis without perforation is believed to occur.
2. Experimental work does not substantiate it, however. The conditions in the human cannot be duplicated.
3. If fluid from the abdominal cavity and gall-bladder could be analyzed chemically and bacteriologically; and if these studies were correlated with pathologic examination of the gall-bladder, valuable data might be obtained. However, usually these patients are desperately ill and the efforts to save life overshadow the urge for experimental investigation.
4. If the patient's condition warrants it, the common duct should be drained.

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# AVULSION FRACTURE OF THE LESSER FEMORAL TROCHANTER

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THE avulsion of the lesser femoral trochanter because of muscular violence is not a common fracture. According to McEachern and Jennings<sup>1</sup> (1931), there

The pain in the left hip, the incapacity of the left leg and the x-ray film demonstrated an avulsion fracture of the lesser femoral trochanter.



FIG. 1. Roentgenogram showing avulsion fracture of the lesser femoral trochanter. (Case 1.)



FIG. 2. Roentgenogram of the fracture three months after the injury. (Case 1.)

have been forty-eight reported cases in the literature. Since that time, seven additional cases have been recorded, bringing the total to fifty-seven, including the two cases reported below.

CASE I. J. S., a white boy, age 13, on November 24, 1937, complained of pain in the left hip and groin. He gave a history of sliding along on ice when suddenly he was seized with severe pain and fell down. He was carried home and subsequently sent to the hospital.

<sup>1</sup> McEACHERN, J. S., and JENNINGS, H. N. Avulsion of the lesser trochanter of the femur. *Canad. M. A. J.*, 25: 449-450 (Oct.) 1931.

Operation is not necessary in these cases. A plaster of Paris hip spica was applied with the knee flexed. The thigh was held in 90 degrees flexion, adducted and slightly internally rotated. After two weeks' hospitalization the patient was discharged with crutches. Six weeks after the accident the cast was removed. The result was excellent.

CASE II. A. R., colored, age 11, came under my observation September 25, 1938. There was a history of sudden severe pain in the right leg while running. This patient also was treated by means of a hip spica, leaving the hospital five days later, and making an uneventful recovery.

# NEW INSTRUMENTS

## A RUBBER-DAM COLOSTOMY MAT

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**F**OLLOWING the operative procedure of the formation of a colostomy, as part of a resection of the rectum, as a

1½ inches long; after the wound has healed and edema has resolved, it should then be cut down to ½ inch above the skin line. This usually can be done at the end of the second week.

A piece of measured tonsil snare wire is placed around the periphery of a circular sheet of rubber-dam, 10 inches in diameter. The edge of the rubber-dam is hemmed over the circular wire, giving us a rubber-dam mat.

All dressings are removed from the wound at the time of removal of the clamp. If agglutination of the stump to the skin is satisfactory, the wound and sutures are painted with tincture of iodine and a strip of iodoform gauze 2 inches wide is placed on the suture line and a sterile dressing is added. One or two strips of wide vaseline gauze covers the sterile dressing except for the opening through which the colostomy stump protrudes.

The sterilized mat (in alcohol) is then punctured in the center and the opening enlarged by traction, enough to enable the mat to be slipped over the colostomy stump and fit snugly. A 6 inch length of a half-inch strip of either iodoform gauze or vaseline gauze is wound around the base of the colostomy stump next to the rubber-dam mat. Additional layers of wide vaseline gauze are placed in coffer-dam arrangement to protect the colostomy. A drainage pad covers all the dressings.

We prefer to initiate colostomy training by enema the following day and we repeat

FIG. 1. Colostomy mat before using.

permanent double-barrelled colostomy, or as a palliative Mikulicz operation, the clamp is usually removed in forty-eight hours postoperatively. At this time a psychic depression unfortunately occurs in most of the patients.

Any procedure which prevents the superimposed burden of a wound infection during postoperative convalescence is to be sought for. A simple device is presented to be used in the postoperative colostomy training until after the stitches have been removed and the wound has healed. The colostomy stump should purposely be left



the enema daily at the same time. This soon trains the lower part of the colon to evacuate itself completely only at the time

repeatedly after cleansing and sterilizing, until the slit becomes too large to fit snugly, when they can be discarded.

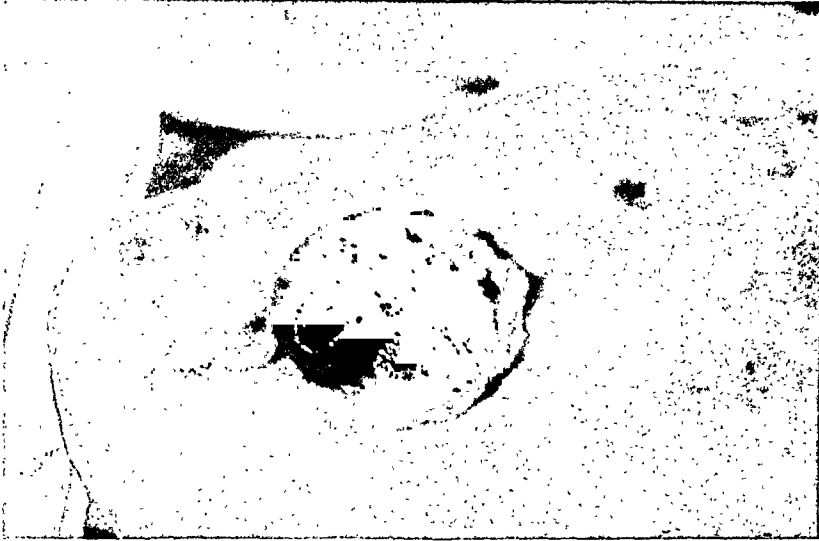


FIG. 2. Colostomy mat in use.

the enema is given. The disagreeable incontinence is avoided.

With each evacuation the rubber-dam mat with its fecal contents is lifted from the colostomy stump and after cleansing, the dressings and mat are replaced as described above. The abdomen is never soiled and the suture line is never contaminated.

With adherence to details on the part of the attendants, all wounds heal by primary union. Three or four rubber-dam mats should always be on hand and may be used

#### CONCLUSION

1. A simple device, a rubber-dam mat, is presented to be used during postoperative training of the colostomy to insure primary healing of wound.
2. It avoids general soiling.
3. Confidence is established in the fact that there is no necessity for a colostomy bag.
4. It is a psychic aid in the management of the depression which follows the formation of an abdominal colostomy.



# TRACTION ON THE ZYGOMATIC PROCESS FOR CERVICOVERTEBRAL INJURIES

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IN the past, traction for cervical injuries by halters and various other methods by applying force under the chin or the

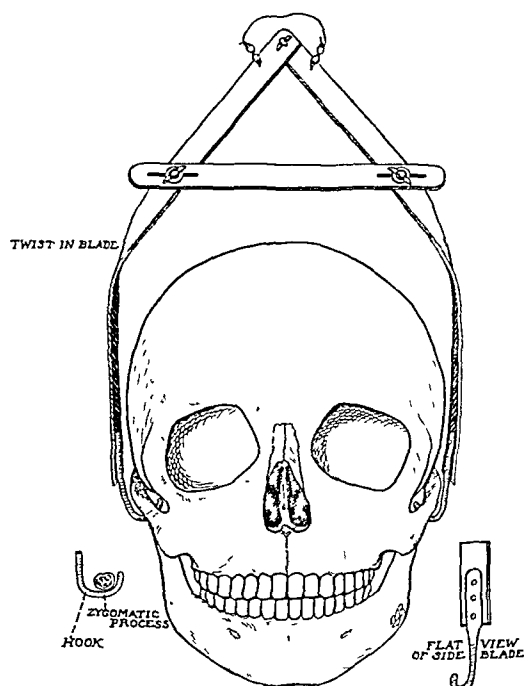


FIG. 1. Traction apparatus applied, showing relation of hook to zygomatic process.

occiput have proved to be very uncomfortable for the patient. Skeletal traction eliminates this disadvantage.

The following apparatus may prove to be a better means of obtaining cervical traction, by making use of the zygomatic process on each side as an anchor post.

The apparatus represents the acme of mechanical simplicity. It consists of two separable side blades with a quarter twist just below the middle of the blade. These two blades are held together at the top by a removable lock bolt. Fastened to the bottom of each blade is a rustproof round hook with a square base wide enough so the outer prong does not compress the skin and

soft tissue over the zygomatic process. Where it is feared this will not prove effective, a flat hook  $\frac{3}{16}$  to  $\frac{1}{4}$  inch wide can be attached. The point of the inside prong or bar is made round and smooth, that no soft tissue injury can be produced. The removable cross bar, which prevents the blades from spreading or coming together, is held in place by two removable bolts. All bolts have winged nuts to facilitate tightening.

The method of inserting the hooks beneath the zygomatic process is simple. With the usual aseptic procedures, 2 per cent procaine is injected under the zygomatic process at its midportion, just in front of the tubercle. The needle is then tilted up as much as possible and procaine injected along the inner surface of the process. A very small nick is made in the skin, enough to allow the hook to pass through. A button hooklike instrument with a round, smooth, dull point is then inserted and directed under and upward around the zygomatic process, always hugging the bone. This grooves a pathway for the hooks which are to follow. The same is done on the other side. The sterilized tractor hooks are then carefully inserted. The top bolt is then put on, followed by the cross bar which is adjusted so the inner post of the hooks are in immediate contact with the inner surface of the zygomatic process. The instrument is now set for traction.

As no pin is drilled or set into the cortex of bone, there is less danger of osteomyelitis, and because the traction hooks or bars are pulling on hard, undamaged bone there is less chance of bone erosion, loosening or cutting through as in the intra-osseous pin or screw.



[From Fernelius' *Universa Medicina*; Geneva, 1679.]

# BOOKSHELF BROWSING

SMOLLETT, LIND AND ANSON IN 1739

THEIR COMMON CONTRIBUTION TO THE CONTROL OF SCURVY

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IN 1739, just 200 years ago, England entered upon a period of warfare with Spain and France. Seventy-six years of intermittent conflict followed. How the ebbing power of Spain and the flood tide of French imperialism were stemmed, and how these empires surrendered vast tracts of their domains as the price of peace—these are the facts of history. England's mastery at sea and economic strength at home won victories not to be bought by Spanish gold, victories of more enduring character than Napoleon's brilliant battles. The year 1739 was momentous in the history of the British Empire, for it was the year in which the birth pains of that empire set in. The political happenings culminated in the establishment of British rule over one-fourth of mankind.

1739 was also a significant year in the history of medicine. Events in the lives of three men in that year led to man's effectual control over the most dreaded of all old-time sea diseases, the scurvy. In 1739, three men, unknown to each other, made important changes in their lives, important for posterity. One went to London. One went to sea. One returned from the West Indies to take command of an expedition fitting out for

the Far East. Their names were Tobias Smollett, James Lind and George Anson. Their achievements in the fields of English literature, medical science and navigation all contributed to the immense improvement in the health of seamen which followed mastery of scurvy in the British Royal Navy, a major triumph of eighteenth century medicine.

England formally declared war against Spain October 23, 1739, but informal war had been in progress many years. Two hundred years ago, just as today, international "incidents" had political value out of proportion to their probable authenticity. Whether or not that charming fellow, Juan de Leon Fandino, captain of His Catholic Majesty's guardacostas in April, 1731, halted and boarded the *Rebecca*, brig, of Glasgow, bound from Jamaica to London, and whether or not Captain Fandino, in protest against an inhospitable reception, clipped an ear from Captain Jenkins's head and made remarks derogatory to the British throne—even today no one can be sure. The fully established, more important fact is that in 1738 Captain Jenkins appeared before Parliament, told his story, offered his ear in evidence, and so excited public indigna-

tion that Walpole was reluctantly compelled to sanction measures of reprisal. In 1739 these measures led to open war,

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MDCCLIII.

FIG. 1. Title Page of Lind's Treatise of the Scurvy, 1753. The date is often misquoted. (Courtesy of New York Academy of Medicine.)

the War of Jenkins's Ear, as it was lightly named. No substantial treaty of peace was to be written until 1815. Events of 1739 were a prelude to suffering and death in the steaming jungles of India, on the wooded slopes of America, on the sands of Egypt and on the heights of Quebec. Events of 1739 bred those of 1776, with Bunker Hill, Princeton, Saratoga and Valley Forge. But it was not on land but on sea that the fate of empires was

determined. The Board of Admiralty, in 1739, had already drawn its plans.

The scheme was olympian in scope. In the Caribbean, in the Pacific and in the South China Sea, attack was to be made on Spanish colonies whose remoteness hitherto had been their chief protection. Two of these three expeditions eventually set sail, the one to the Caribbean under Vice-Admiral Edward Vernon departing August 3, 1739. Admiral Vernon was on no mission of appeasement. His orders, dated July 19, 1739, three months before formal declaration of war, instructed him "to destroy the Spanish settlements in the West Indies and to distress their shipping by every method whatever." That was undeclared war with grim vengeance! Destined to serve under Admiral Vernon in the humble capacity of surgeon's mate, was England's greatest physician-novelist, Tobias Smollett, but in 1739 he was unaware of that destiny.

Tobias Smollett was born in the valley of Leven in Scotland in 1721. In 1736 he was apprenticed to Dr. John Gordon of Glasgow, where he was a fellow student of William Hunter. For three years he pursued his studies. Then, in 1739, came a momentous decision: he would go up to London, mecca of young Scotsmen on the make. Perhaps Smollett's motives are revealed in the persuasive arguments addressed to Roderick Random by that worthy and vigorous surgeon, Mr. Launcelot Crab: "I am surprised that a young fellow like you discovers no inclination to push his fortune in the world. Before I was of your age, I was broiling on the coast of Guinea. Damme! what's to hinder you from profiting by the war, which will certainly be declared in a short time against Spain? You may easily get on board of a king's ship in quality of surgeon's mate, where you will certainly see a good deal of practice, and stand a good chance of getting prize money."

It was the first day of November, 1739, when Roderick Random took his leave of Mr. Crab and set out with carriers bound

for Newcastle. The year is known to be that of Smollett's London journey; no doubt the day and month are those given, and no doubt the inventory of Rory Random's kit is the tally of Smollett's worldly wealth at this important juncture in his career: "One suit of clothes, half a dozen of ruffled shirts, as many plain; two pairs of worsted, and the like number of thread stockings; a case of pocket instruments, a small edition of Horace, Wiseman's *Surgery*, and ten guineas in cash; for which Crab took my bond, bearing 5 per cent interest." One item known to be carried by Smollett is missing from the list: the manuscript of his first magnum opus, a tragedy, hopelessly bad, which he had written when he might better have been studying his Wiseman.

It was in 1739 that Smollett made this important journey, and when, in October, 1740, Rear Admiral Sir Chaloner Ogle sailed for Jamaica with men and supplies for Admiral Vernon, one of his ships carried as surgeon's second mate the raw young Scot whose immortal record of his experiences at sea took shape in 1748 as the first great English maritime novel, *The Adventures of Roderick Random*.

*Roderick Random* was more than a narrative. In describing the cockpit, the sickbay, the rationing, the treatment of the sick and the squalor and horror below decks, Smollett revealed the appalling indifference of the Admiralty to the welfare of the men and the urgent need for hygienic reform. Sent out between the covers of a best seller, Smollett's revelations had wider circulation than if they had been issued as a tract on naval hygiene, and they were more effective, because they were read. By exposing the crudities of naval hygiene in the blaze of his satire, Smollett made an important contribution to its ultimate amelioration. Good general hygiene is a most potent force in the control of scurvy.

Smollett's contribution to the control of scurvy by propaganda for the general improvement of naval hygiene was inci-

dental to his main purpose: to sell a novel. Another Scotsman was to have as his first aim, not the writing of a novel, but the composition of a volume on scurvy that would serve as a record of his observations and the observations of all earlier writers on the subject. That purpose had not been conceived in 1739, but in that year this other Scotsman, James Lind, went to sea, and out of his experiences there that purpose and its fruition came.

James Lind was born in Edinburgh October 4, 1716. At the age of 15, he, like Smollett, was booked apprentice. Smollett worked three years for Dr. Gordon; Lind served Mr. George Langlands, surgeon, of Edinburgh, the full seven-year term. Then, in 1739, with little prospect of advancement in Edinburgh, for reasons perhaps resembling those which influenced Roderick Random, Lind went up for a surgeon's mate's warrant, received it, and embarked in one of His Majesty's ships.

Lind remained in the Royal Navy for nine years, whereas Smollett spent only two. By 1748, the year of Lind's retirement, Smollett had been ashore six years; and had finished *Roderick Random*. Lind, too, had experiences to place on record, but not in the form of fiction. In 1753 appeared *A Treatise of the Scurvy*, a work that remains today an enduring monument to Lind's fame, as important to science as *Roderick Random* is to literature. Lind sifted a kitchen midden of sea lore, medical dogma, false deduction and half expressed truth. Guided by his own observations and by his practical knowledge of the disease, he laid the sound foundations of modern diagnosis and treatment. He was not the first to propose the use of citrus fruit juices in treatment of scurvy (he stated himself that "their experienced virtues have stood the test of near 200 years") but he was the first to review as completely as he could all previous work on the subject and compare other authors' conclusions with his own by the test of experimentation. After Lind, no further demonstration was needed

that orange and lemon juice were superior to all other remedies in the treatment and prevention of scurvy.

"On the 20th of May 1747, I took twelve patients in the scurvy, on board the Salisbury at sea. Their cases were as similar as I could have them. . . . They lay together in one place, . . . and had one diet common to all . . .

"Two of these were ordered each a quart of cyder a-day. Two others took twenty-five gutts of *elixir vitriol* three times a-day . . . Two others took two spoonfuls of vinegar three times a-day . . . Two of the worst patients . . . were put under a course of sea water. Two others had each two oranges and one lemon given them every day. The two remaining patients, took the bigness of a nutmeg three times a-day, of an electuary . . . made of garlic, mustard-seed, *rad. raphan*, balsam of Peru, and gum myrrh.

"The consequence was, that the most sudden and visible good effects were perceived from the use of the oranges and lemons; one of those who had taken them, being at the end of six days fit for duty . . . The other was the best recovered of any in his condition; and being now deemed pretty well, was appointed nurse to the rest of the sick."

In medical literature there are few experiments more convincing than that one of Lind's. Many years were to pass, and Lind himself was to be in his grave before the simple measures he proposed were to find favor with the august Lords of the Admiralty through the influence of Sir Gilbert Blane. When, in 1795, Lind's observations were applied, and an order was given that lemon juice was to be issued daily on all ships after two weeks on salt meat, scurvy was banished from the British navy.

The first edition of *A Treatise of the Scurvy* is dedicated to the Right Honorable George, Lord Anson "who, as a just reward for the great and signal services done to the British nation, does now preside over her naval affairs." In the introduction Lind acknowledges that it was publication of the account of Anson's circumnavigation of the globe which first led him

to think of writing the book which made him immortal.

George Anson was born in Staffordshire in 1697. At the age of fifteen he entered the navy and ten years later, in 1722, was given his first independent command. Seventeen years of active service followed. In 1739 his great opportunity came. By the Admiralty plan, a man was needed to command one of the squadrons which was to be sent out to fight the Spaniard on the other side of the world. Anson was chosen and recalled from his station in America to play a rôle in which he was to capture and forever hold the imagination of a maritime race. His mission, as finally conceived, was a dangerous one. He was to round the Horn, and, while Vernon operated in the Caribbean, he was to "distress and annoy the King of Spain and his subjects" along the west coast of South and Central America. The eight vessels of Anson's squadron put to sea September 18, 1740. Anson was a brilliant leader. English seamen were superior to those of any other nation. Three ships survived the Horn, but after rounding it, they were no longer effective vessels of war. No extensive campaign could be undertaken, and all thought of the substitution of English for Spanish rule in Central and South America was at an end. Scurvy had taken its toll. Let Chaplain Richard Walter describe conditions aboard Anson's flagship:

"Soon after our passing Straits Le Maire, the scurvy began to make its appearance amongst us; and our long continuance at sea, the fatigue we underwent, and the various disappointments we met with, had occasioned its spreading to such a degree, that at the latter end of April there were but few on board, who were not in some degree afflicted with it, and in that month no less than forty-three died of it on board the *Centurion* . . . in the month of May we lost near double that number: and as we did not get to land till the middle of June, the mortality went on increasing, and the disease extended itself so prodigiously, that after the loss of above two hundred men, we

could not at last muster more than six foremost men in a watch capable of duty; . . . to so wretched a condition was a sixty-gun ship reduced, which had passed Straits Le Maire but three months before, with between four and five hundred men, almost all of them in health and vigour . . . ”

Two hours to trim the sails; four hours to heave the anchor cable up and down, and then unable to start it because the capstan was so weakly manned! A long period of rest and recuperation at Juan Fernandez restored many to health, but those who had died could not be replaced, and of 961 men comprising the original crews of the three vessels which reached Juan Fernandez, only 335 were living in September, 1741, most of the 626 dead having succumbed to scurvy.

Anson returned, laden with booty, in 1744 and Chaplain Walter, in 1748, the year of *Roderick Random* and the year of Lind's return to Edinburgh, published *A Voyage Round the World in the Years 1740-1-2-3-4* by George Anson, Esq., now Lord Anson, which ran to four editions in the first year. The ravages of scurvy were described with overwhelming force, while the dramatic events of Anson's voyage aroused intense popular interest. Lind was only one of many who must have been stirred by the pitiful account of brave men crippled and destroyed by scurvy. With them died English dreams of a South American empire, but their deaths and Chaplain Walter's telling made men aware of the cruel extent of scurvy's ravages at sea and directly led to Lind's great treatise.

Anson returned to occupy the highest posts in the Admiralty and became Admiral of the Fleet before his death in 1762. He was First Lord when Lind dedicated his *Treatise* to him; as First Lord in 1758 he appointed Lind physician to the new Naval Hospital at Haslar, a post Lind occupied for many years. Lind died in 1794, at the age

of 78. Smollett pursued that fickle hussy, literary fame, with variable success. Never was he further from her favor than when, in 1769, he produced *The History and Adventures of an Atom*, which is mentioned here only because of the bitter lampoon of the dead Admiral Anson under the soubriquet of Nin-kom-poo-po. Smollett was, however, an ailing man and he survived only long enough to finish *The Expedition of Humphrey Clinker* which appeared in 1771.

Smollett, Lind and Anson live as long as books are treasured and read. Two hundred years ago their destinies took definitive shape. Their single important common experience, naval service, gave us a novel, prototype of naval fiction; a treatise, greatest of its kind; and a travel narrative, yet unsurpassed, all three of which contributed to one of man's grandest medical victories, control of scurvy.

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# The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

## EDITORIAL

### EMERGENCY SURGERY

**N**CESSITY for prompt action differentiates emergency from elective surgery. In general, surgical emergencies arise in persons previously well and as such they receive medical attention without much delay. On the other hand, chronically ill patients who develop acute surgical conditions do not fare so well, for the urgency of their condition may be overlooked by the medical attendant, or a serious operation may be undertaken hastily without adequate preoperative preparation. The tendency to regard new complaints as trivial is not confined to the general practitioner, for attending hospital surgeons are just as prone to err. This state of affairs has given rise to the comment that the worst place for a peptic ulcer to perforate is in a hospital.

In the early days of the craft, surgical emergencies and operations were synonymous terms, but this association no longer exists with the passing of the period when the surgeon's training consisted simply of learning to operate. It was only when the curriculum began to include training in when, as well as how, to operate that decisions regarding operation were considered within the surgeon's province. It is, of course, now recognized that the surgeon's decision not to operate is just as important as the decision to operate, but this belated recognition has not always been freely given.

The Halsted system of surgical apprenticeships with its emphasis on pathology and its development of physiologic operative procedures based on animal experimentation has brought forth a concept of surgical problems in which the patient, not the operation, plays the major rôle. In this respect the present day surgeon fulfills Osler's requirement and truly is a physician who operates. He no longer is content to be simply an operator but insists on solving the purely non-operative problems of surgery, a task for which he is preëminently fitted by virtue of his adequate training.

The modern surgeon too has been quick to adopt the contributions of the pure scientist and laboratory worker and to apply discoveries in the basic sciences to everyday surgery. As a specific instance of this we wish to cite the recent revival of our interest in antiseptics. Modern surgery began with the introduction of antiseptics and progress since then has been founded on the principles of antiseptic surgery as evolved and taught by Lister. With increasing knowledge of bacteria the aseptic school of surgery has almost supplanted the antiseptic school. The pendulum has swung so far that at a recent symposium on the treatment of wounds only a single voice was raised in defense of antiseptics. The disrepute of antiseptics is due to their destructive action on the



living cell since with most antiseptics in common use bactericidal activity is proportionate to tissue toxicity. In a study of antiseptics, Dr. Frank Hartman, Director of Laboratories at the Henry Ford Hospital has produced a combination of antiseptic agents which closely approximates the ideal because of its high phenol coefficient and low tissue toxicity. This antiseptic, hexyl-chlor-m-cresol, has been subjected to extensive clinical application and has yielded results superior to those encountered with any of the commercial antiseptics.

The renaissance of surgery reflected in all branches of surgical practice is well exemplified in the modern management of surgical emergencies. The day has gone when patients are rushed into the operating room and subjected to immediate operation. Surgeons of that period, because of the emphasis laid on manual dexterity, placed all their faith in the operation alone and took too little cognizance of the patient's condition. A comparison of mortality rates then and now emphasizes this point. The low mortality rate of today does not necessarily indicate that the present day surgeon is a better operator, but it does mean that he takes better care of his patients.

Perhaps nowhere in the practice of medicine is the exercise of mature judgment founded on experience of more importance than in the handling of surgical emergencies, and yet it is common practice in most hospitals to relegate this responsibility to junior staff members. It is a tribute to present day training that in spite of this seeming paradox the mortality of emergency surgery has steadily decreased in the past decade. This improvement is due to an appreciation of the necessity for restoration of body fluids, glucose, sodium chloride, plasma protein, hemoglobin, vitamins c and k, and other important factors to a normal level, to realization of the importance of adequate supportive measures in forestalling and combating shock and to the more general

use of local and in certain cases spinal anesthesia for these operations.

Emergency operations are at best hazardous undertakings. Most of them occur at night when the surgeon is often fatigued and when even in the best hospitals the operating room staff is not so alert as in the day time. Frequently assistance is inadequate, full equipment and supplies are not available and administration of the anesthetic is far from ideal. It is not surprising that the mortality for operations performed as emergencies is higher than for the same procedures carried out on a previously established schedule.

Surgical emergencies may be classified according to their urgency into three groups: Group I, in which immediate operation without preparation is indicated, as for example uncontrolled external hemorrhage or massive internal hemorrhage; Group II, which requires operation as soon as dehydration is controlled, as for example acute appendicitis, perforated peptic ulcer, strangulated hernia, etc.; Group III, when operation is best deferred until the patient's general condition is improved by adequate treatment, as for example appendicitis with general peritonitis, certain cases of acute pancreatitis, intestinal obstruction, etc.

Except for cases falling into Group I there is no indication for unnecessary haste in operating. Surgical intervention should be deferred until blood has been obtained for grouping and intravenous fluids have been administered. This delay will enable the surgeon to assess the patient's general condition and obtain a second opinion when the diagnosis is not entirely clear. Time spent in preparing patients for operation will pay big dividends in the form of lowered mortality and decreased morbidity. All these points and more have been emphasized over and over again by our contributors who have endeavored to make this volume thoroughly practical by avoiding controversial points and by presenting methods which they have found successful in their own practices.

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# ORIGINAL ARTICLES

## ANESTHESIA FOR EMERGENCIES\*

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WHILE the general principles governing anesthesia for surgical emergencies are precisely the same as those for ordinary surgery, there are certain conditions present at these operations which have an important bearing on the choice and management of the anesthesia. These conditions are (1) lack of time, (2) the possibility of a full stomach, and frequently (3) the presence of shock.

1. From the very nature of things time is not usually available for all the preparatory measures usually considered advisable when deliberate surgery is concerned, such as complete history and physical examination, thorough laboratory work, and a period of rest in bed for sedation and hospital acclimatization, as well as measures designed to correct abnormalities or to improve the patient's condition, such as infusion or clysis, transfusion, and gastric lavage. Except in most pressing emergencies, however, such as asphyxia or severe hemorrhage, some sort of brief history may usually be obtained, perhaps from family or friends, a physical examination of sorts may be performed, and some laboratory data obtained, such as urinalysis and blood counts. Thus a fair idea of the patient's general physical status and of the presence of any abnormalities may usually be had. Infusions, even if not completed before the operation, may usually at least be started and can be kept running during operation, often to great advantage.

2. Even if operation does not take place for some time after the last meal, a full stomach may nevertheless be present. If

the emergency arises within a short period (less than three hours) after the meal, whether the emergency is of a natural sort, such as acute appendicitis or strangulated hernia, or is of an accidental nature, such as an automobile or industrial accident or human violence (bullet or stab wounds), in either case digestion is usually stopped, and thus, even if operation does not take place till some hours later the stomach will usually be full of partly digested food.

The possibility of undigested food in the stomach should always be kept strongly in mind as this is one of the most important considerations in these cases, inattention to which may prove quite disastrous. Careful consideration should, therefore, be given to the character of the last meal and to the time elapsing from then to the occurrence of the emergency. It must always be remembered that it is this period of time and not the period to the time of operation which is so important. If there is any doubt about it, if, for instance, the last meal was not reasonably digestible, or if less than three hours elapsed thereafter before the emergency arose, it is safer to presume that at least some food is still present in the stomach.

The importance of this whole problem of food in the stomach can hardly be exaggerated, since it is a factor which may wreck and bring to naught an operative procedure otherwise well planned and successfully executed. For if the patient should vomit at a time when the throat reflexes which guard the larynx were sufficiently obtunded he might very well aspirate some

\* From the Department of Anesthesia, Lahey Clinic, Boston, Massachusetts.

of the vomitus into the lungs with the subsequent production of atelectasis or pneumonia, very likely with a fatal termination. It is this possibility which makes the question of food in the stomach of paramount importance in these cases.

When, therefore, after careful investigation there is still doubt that there may possibly be food left in the stomach an anesthetic should be chosen which does not obtund the protective throat reflexes. This means that local, regional, or spinal anesthesia is the anesthesia of choice, and that general anesthesia should not be employed if it is in any way possible to get along without it.

When local or regional anesthesia are suitable for the surgical procedure and give satisfactory operating conditions they are excellent. Such cases are most apt to occur in traumatic surgery of the extremities. Thus local anesthesia may be used for the reduction of simple fractures and regional anesthesia for localized trauma such as knife or bullet wounds. Field block is also excellent for scalp wounds. In abdominal operations local and regional anesthesia are usually unsatisfactory unless combined with a general anesthetic, and spinal anesthesia therefore becomes the anesthesia of choice. It is often also the best choice for operations on the lower extremities particularly if suture of tendons is involved. It is particularly indicated in operations for acute appendicitis not only because it lessens the danger of aspiration of vomitus but also because under it the danger of spreading the infection from the appendix to other parts of the abdominal cavity is reduced to a minimum. Under inhalation anesthesia the heaving abdomen and often the lack of complete relaxation make it difficult to keep infection localized but under spinal anesthesia the quiet abdomen and utter relaxation make conditions as favorable as they possibly can be for such localization. Unless contraindicated by the condition of the patient it is also the anesthesia of choice in strangulated hernia and intestinal obstruction. Not only does it

lessen danger of aspiration as compared with general anesthesia but also it upsets the patient less and is followed by less nausea and vomiting. In our experience with these patients it has usually been followed by notably good recovery. With strangulated hernia, however, it is sometimes desirable to use a non-relaxing anesthesia such as gas oxygen, so that a gangrenous piece of gut may not fall back into the abdomen and be lost.

If spinal anesthesia is used for an operation for perforated gastric ulcer or for other abdominal operation in which infection is present and after which steep Fowler's position may be indicated, it is well to remember that if a 20 or 21 gauge spinal needle, such as is commonly used by most anesthetists, is employed, the patient will be almost sure to develop a very severe headache when Fowler's position is assumed. On the other hand, if a 24 gauge or smaller needle is used this will probably not occur even though Fowler's position is assumed shortly after operation.\* Of course, due care must be taken when the patient is placed in this position to see that cerebral anemia does not occur. This can be immediately remedied, however, by lowering the patient's head.

Many surgeons and anesthetists question the propriety of using spinal anesthesia in perforations of the stomach or intestines because of the danger that the contractions of these organs caused by spinal anesthesia may squeeze further contents out into the peritoneal cavity, thus causing peritonitis. We have never felt that this danger was great enough to justify foregoing the other manifest advantages of this anesthesia.

In all this discussion of spinal anesthesia it is assumed that the administration is by a competent anesthetist who is thoroughly familiar with this particular form of anesthesia, for otherwise it may be quite dangerous. If such an anesthetist is not available it would probably be safer to use

\* SISE, L. F. A method for the prevention of post-puncture headache in cases of low spinal anesthesia. *S. Clin. North America*, 19: 695-698 (June) 1939.

some other form of anesthesia. This precaution is quite important, since there are few methods of anesthesia in which safety is so dependent on the skill and experience of the one who administers it.

When for any reason the first choices of local, regional or spinal anesthesia cannot be employed in these cases, the second choices of gas-oxygen or gas-oxygen-ether\* should be used. These inhalation anesthetics are less desirable than the first choices both as regards aspiration of vomitus and, with the exception of spinal anesthesia, as regards shock. For protection against aspiration it is the practice of some anesthesiologists when using these anesthetics to stop administering the anesthetic in the induction period so that the patient will recover and vomit, with the hope that the stomach will be emptied of any food that is in it and that full anesthesia can then be resumed with safety. This measure has its advantages, chief of which is its simplicity. It does not, however, ensure that the emptying of the stomach is complete and that vomiting cannot take place again later on. Also, the passage of vomitus through the throat renders it extremely acid. It is well known that the secretions of the throat may find their way into the lungs during any ordinary general anesthesia. Under ordinary circumstances these are quickly gotten rid of on recovery and appear to do no harm. But if they have recently been made strongly acid by the passage of vomitus with perhaps some small food particles left behind, it may well be that they are not so innocuous and that they may cause at least an irritative bronchitis and possibly atelectasis or pneumonia. It seems preferable, therefore, instead of trusting that vomiting will empty the stomach, to make definitely sure that it is empty by means of a thorough gastric lavage, if the circumstances are such that this is practical.

When the circumstances are such that gastric lavage cannot be done we prefer

\* Throughout this paper the word "gas" is taken to signify nitrous oxide, ethylene, or cyclopropane.

to intube the patient with an intratracheal airway. Induction should be rapid and anesthesia deep for intubation so that the patient will not vomit before intubation is complete. If in spite of these precautions he does vomit, the mouth and throat should be carefully cleaned by suction and the trachea inspected. If there has been no aspiration, intubation may be done, but if aspiration has occurred bronchoscopy should be carried out immediately, if the surgical condition is such that this is allowable, and any foreign material in the trachea or bronchi carefully removed by suction, after which intubation may be completed.

When the intratracheal tube has finally been placed in position the gas supply should be connected directly to it with a pressure of approximately 12 mm. of mercury in the breathing bag.

The patient is now safe from further danger of aspiration. The pressure in the breathing bag ensures that all inspiration takes place through the intratracheal tube and that none occurs in the space around the tube, the only space where aspiration could otherwise occur. Because of the pressure in the breathing bag, expiration through this space around the tube is much stronger and of larger volume than usual, so that aspiration becomes impossible. Intratracheal gas-oxygen is especially suitable for operation in injuries of the head, face, or mouth, but covers satisfactorily a wide range of other operations.

If during a general anesthesia, whether or not an intratracheal tube is in place, vomiting takes place if there is the slightest doubt that aspiration may have occurred bronchoscopy should be done immediately at the conclusion of the operation. This may well be done by the anesthetist. Anyone who is thoroughly familiar with intubation by direct laryngoscopy (as every anesthetist should be) can very readily learn bronchoscopy, and, as time is very important, his presence on the spot marks the anesthetist as the logical man for this procedure.

3. The effect of the presence of shock on the choice of anesthesia is in no way different from that in ordinary non-emergency surgery. It does, however, limit the choice of anesthesia still further, since any anesthesia such as spinal or ether, which tends to intensify it would probably be contraindicated. Under these circumstances, if local or regional anesthesia, the first choices, would be insufficient for the operation, resort must be had to the second choice of gas-oxygen or gas-oxygen ether as mentioned above. If the operation is abdominal, field block will be of considerable help by producing muscular relaxation at least at the immediate site of operation.

The anesthetist may well concern himself also with the treatment of shock when it is present, but such treatment has been so thoroughly covered elsewhere that it will not be considered here.

#### SUMMARY

While the general principles involved in anesthesia for emergency operations are identical with those for deliberate surgery, the conditions usually present in emergencies make much greater demands on the

anesthesia and curtail the available number of choices while at the same time limiting the data from which a judgment of the choice must be made. These conditions are (1) lack of time for gathering data about the case and for preparing the patient for anesthesia and operation, (2) the probability of food in the stomach, and often (3) the presence of shock.

The presence of partly digested food in the stomach is a most important complication, which may lead to severe post-operative complications and even death unless properly handled. For this reason local, regional, or spinal anesthesia is usually first choice and intratracheal gas-oxygen or gas-oxygen-ether is second choice. Spinal anesthesia is extremely useful, especially when the operation is abdominal, but should be administered only by one thoroughly familiar with its use. Bronchoscopic examination and drainage are often useful and may be life saving, and may be done to advantage by the anesthetist.

If shock is present the use of spinal, or ether anesthesia is usually inadvisable and local, regional, or gas-oxygen anesthesia or a combination of these is to be preferred.



# SHOCK\*

## A CONSIDERATION OF PREVENTION AND TREATMENT

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THE findings in shock are well known,<sup>1</sup> including pallor, sometimes with slight cyanosis; a cold, moist or sweaty skin; a rapid, regular, but thready pulse; rapid, usually shallow respirations; restlessness and an appearance of anxiety which may change to dulness and lessened sensitivity; thirst; a variable amount of nausea and sometimes vomiting. The temperature is usually subnormal, the blood pressure is low, or falling, the red count and hemoglobin may be low, normal or high, depending on the relation between the loss of whole blood and of plasma. Most important, there is a diminution in the effective volume of circulating blood.

The classical cause of shock is severe trauma in which large masses of tissue are crushed, often in association with fractures of long bones. Hemorrhage, whether external or concealed, if of sufficient quantity, leads to shock. Surgical operations, burns, freezing, intestinal strangulation, peritonitis and many so called "medical diseases" may be associated with the development of shock.

All cases of shock are not referable to one etiology and various classifications have been devised to distinguish them. Thus primary and secondary shock have been long used. Primary shock refers to the immediate collapse following injury, as contrasted with secondary shock which comes on after a variable interval following the trauma.

Primary shock has usually been interpreted as the immediate reaction of the nervous system to trauma similar to ordi-

nary syncope, initiated by a peripheral vasodilatation, probably in the splanchnic area, with a sudden fall in blood pressure leading to unconsciousness. Primary shock often merges imperceptibly into secondary shock. The work of O'Shaughnessy and Slome<sup>2</sup> suggests that primary and secondary shock are different stages of one and the same process.

We have suggested a physiologic classification of acute circulatory failure, the different types being designated as hematogenic, neurogenic and vasogenic.<sup>3</sup> Hematogenic refers to those instances in which there is an initial decrease in the blood volume which is followed by vasoconstriction and a decrease in the output of the heart and subsequently by a decline in the blood pressure. The conditions associated with simple hemorrhage and trauma to muscles are examples of this type. The neurogenic type is associated with vasodilatation which is dependent on diminished constrictor tone as a result of influences acting through the nervous system. The blood pressure declines first and subsequently there is decrease in the blood volume and the cardiac output. The vasogenic type is associated with vasodilatation which is produced by agencies which act directly on the vessels. Histamine probably exerts most of its effect in this manner. Unfortunately, most instances of shock as observed in patients are complicated and may be combinations of the different types. For example, many different factors may enter into the development and maintenance of shock associated with

\* From the Department of Surgery, Vanderbilt University. Aided by a Grant from the Division of Medical Sciences of the Rockefeller Foundation.

operations. Not the least of these is the fact that the patient is usually ill at the time that the operation is undertaken.

It has long been known that an important feature of shock is a decreased blood volume. The initiating factor in shock due to gross trauma is probably blood and plasma loss in and near the site of trauma.<sup>4,5</sup> Harkins and Roome<sup>6</sup> have measured the amount of swelling occurring in human traumatic injuries, finding amounts as high as 1,500 c.c. of blood or plasma lost into the traumatized tissues in some cases. In less serious injuries, as the crushing of a hand or forearm, 600 c.c. of fluid was estimated to be lost into the tissues. They point out that such concealed hemorrhage and plasma exudation may reach considerable amounts without being suspected on casual examination. Secondary factors also operate to aid in the production of shock. These include pain, fear, cold, starvation or dehydration, anesthesia and preëxisting disease. Freeman<sup>7</sup> has suggested that these factors act by vasoconstriction to increase tissue anoxemia and capillary injury, with a resulting increase in plasma loss.

Shock will be considered from the viewpoints of prevention and of treatment. Obviously, there is of necessity some overlapping as prevention and treatment are often one and the same.

#### PREVENTION

The ideal objective to be sought for is the prevention of the full blown picture of shock. As the condition progresses, the changes taking place may become irreversible and treatment becomes of less avail. Much can be done in the prevention of shock, particularly in elective surgical procedures. Since dehydration, by reducing the amount of available fluid, is a factor in the development of shock, patients should have adequate fluids. Purgation before operation should be avoided because of the fluid loss that it entails. In the presence of diarrhea or vomiting, this fluid loss should be made good. Collier et al.<sup>8</sup> have

pointed out that the chloride requirement can be satisfied by the parenteral administration of 0.9 per cent sodium chloride solution, equal in amount to the loss due to vomiting or diarrhea. In the absence of vomiting or diarrhea, the daily water requirement has been shown by Collier and Maddock<sup>9</sup> to average 3,500 c.c. per day. This may be given orally, subcutaneously, or intravenously, preferably by one of the former two routes. In the presence of diarrhea or vomiting this fluid requirement will be increased. Fluid loss during operation may be great, as Collier and Maddock<sup>10</sup> have shown. They found during operation and a four hour recovery period that a liter of fluid was lost in the average case, 70 per cent of this through the skin and lungs. In prolonged operations as much as 2 liters might be lost. Replacement of this fluid should be cared for. Holman<sup>11</sup> has suggested that patients receive 1,000 c.c. of 10 per cent glucose intravenously two hours before operation, in addition to fluids during operation. The introduction of blood is preferable to solutions of crystalloids if the operation is a protracted one and the loss of blood is great. By hypodermoclysis in the thighs, patients may be given from 750 to 2,000 c.c. of physiologic saline during the course of the usual operation, to guard adequately against dehydration.

The general nutrition of the patient, as well as salt and water must be considered. Holman<sup>11</sup> points out that the undernourished patient with a hypoproteinemia, in whom the vitamin store is low, is not in fit shape for the ordeal of an operation. He advises that in elective operations, patients should be placed for ten days on a high vitamin diet with the addition of concentrated vitamins, namely haliver oil 2 capsules t.i.d. for vitamins A and D; brewers' yeast powder, one heaping teaspoonful t.i.d. in fruit juice for the vitamin B complex; and the juice of four oranges and two lemons daily for vitamin C. For the anemic patient, liver, iron and concentrated vitamins are to be particularly stressed. Transfusions may be necessary,

with the aim to obtain a hemoglobin of 60 per cent, although Holman states that one occasionally will have to be satisfied with 40 per cent.

The recent discovery of the rôle of vitamin  $\kappa$  in the production of prothrombin and its relation to the hemorrhage occurring in jaundice offers an excellent opportunity for the prevention of shock due to hemorrhage which is so often seen post-operatively in these patients. Quick<sup>12</sup> has devised a test for prothrombin deficiency, reduction of which to 20 per cent of normal is apt to be followed by bleeding. Snell, Butt and Osterberg<sup>13</sup> have reported excellent results from the administration of vitamin  $\kappa$  in combination with bile salts, in the prevention of hemorrhage in jaundiced patients, and in the treatment of active bleeding. Vitamin  $\kappa$  and bile salts are given preoperatively, until the prothrombin is elevated to normal. Where bleeding is present, transfusion is indicated to be followed by the administration of vitamin  $\kappa$  and bile. They point out that the greatest danger from the hemorrhage occurs from the third to ninth day post-operatively, so that treatment should be continued after operation.

Attention to careful hemostasis and avoidance of unnecessary trauma during the performance of operations will aid in the prevention of shock. Gatch and Little<sup>14</sup> measured the amount of blood lost during operations, finding that 50 to 300 c.c. might be lost in abdominal operations, and with such procedures as mastectomy or thyroidectomy the amounts might be as great as 400 to 700 c.c. Such a blood loss, combined with the other shock-producing influences of a major operation, may play an important rôle in the fall in blood pressure and should, therefore, be kept at a minimum.

The patient's body heat should be conserved during operations. Considerable heat may be lost by evaporation occurring from large area of peritoneum or muscle which may be exposed, particularly when moist sponges or packs are used. The

evaporation of water from the surfaces may result in a great loss of heat unless care is taken to see that warm sponges are used. The room should be comfortably warm. Excessive heat tending to cause marked sweating by the patient is to be avoided.

The choice of the anesthetic agent must be considered in relation to shock. Ether anesthesia has a greater tendency to depress the blood pressure than nitrous oxide-oxygen. In long, tedious operations where relaxation is necessary, the use of ether, by minimizing the amount of trauma necessary, may outweigh its depressing action on the blood pressure. It is desirable that a high percentage of oxygen be used in combination with ether.<sup>15</sup> The dangers of anoxemia have been emphasized by Hartman and McClure.<sup>16</sup> Different viewpoints are held in regard to the use of spinal anesthesia when shock is feared.<sup>2,17</sup> Burch, Harrison and Blalock<sup>18</sup> have shown that the tolerance to hemorrhage is less under spinal than under ether anesthesia. Local anesthesia should be used whenever it meets the requirements.

In operative procedures of great severity, or when the patient's condition leads one to suspect that some degree of shock may follow operation, a blood donor should always be available. The cross agglutination tests should have been performed, so that if blood is needed, it can be given at once. A decline in blood pressure to below 90 after operation should indicate the necessity for blood transfusion. In fact, many believe that every operation of the magnitude of a thoracoplasty, for example, should be followed by a transfusion.

Good postoperative care will aid in the prevention of shock. Following operation, warm dry gown and blankets should be applied. Excessive sweating, because of the fluid loss, should be avoided. An adequate fluid intake, either oral or parenteral should be maintained, as noted before. Edema should be watched for. Coller, Dick and Maddock<sup>18a</sup> found that in sick patients receiving intravenous



fluids, usually 3,500 c.c. daily, when 0.9 per cent saline or 5 per cent glucose in saline was given, there was an increase in body weight due to fluid retention, often with dependent edema. When glucose in distilled water was given, the excess water was excreted.

Wangensteen and Paine<sup>19</sup> and Miller and Abbott<sup>20</sup> have devised means for decompressing the distended intestinal tract. In instances in which strangulation is not feared, the operation can be made easier both for the surgeon and the patient if the distention is relieved. Frequently, it will be found that an operation is not necessary. During the time that the distention is being treated, the general condition of the patient may be improved by fluid administration, etc.

Fractures should be immobilized in temporary splints, preferably before the patient is transferred from the scene of the accident to the hospital. Two purposes are served by splints. Pain is decreased and further damage to the soft tissues by bony fragments is prevented.

A vigorous effort should be made to control diabetes in patients in whom an operation is contemplated. Patients with Addison's disease should receive large doses of cortical extract prior to operation.

#### TREATMENT

As a preliminary to treatment, one should determine if possible the principal cause for the development of shock. This is important because all declines in the blood pressure are not due to the same cause and are not of the same significance. For example, a decline in blood pressure associated with vasodilatation which may follow an operation on the central nervous system is not of as grave significance as a similar decline in blood pressure accompanied by vasoconstriction which may follow simple hemorrhage or trauma to large masses of tissues. In the latter condition, the blood volume is markedly diminished and the supply of blood and oxygen to the tissues is

greatly decreased. For this reason, if immediate treatment is not carried out, irreparable damage to the tissues is apt to occur. Furthermore, since vasoconstriction is already present, the use of drugs which cause constriction of the vessels can do little if any good and may result in harm. The circulating blood volume is reduced and attempts should be made to augment it. On the other hand, if the decline in blood pressure is associated with vasodilatation rather than vasoconstriction and if the blood volume is not reduced greatly, the use of vasoconstrictor drugs may result favorably. Furthermore, the decline in blood pressure is tolerated better since the blood volume may be essentially normal and the supply of blood and oxygen to the tissues not so greatly reduced. It is important to bear these differences in mind in evaluating the effects of therapy.

In the care of traumatic injuries, it is important to estimate the degree of injury, so that if shock is to be expected, no time will be lost in beginning its treatment. Where multiple fractures or injury of large amounts of soft tissue, either with or without external hemorrhage, are present, shock is to be expected, and arrangements should be begun at once to obtain a donor for blood transfusion. Hemorrhage should be arrested as quickly as possible. This can usually be done by a compression bandage or digital pressure. Tourniquets must be used with a good deal of circumspection. If an extremity is hopelessly destroyed, a tourniquet may be applied, left on, and amputation done above the tourniquet, without removing it. But if the member is to be saved, a tourniquet should not be applied unless for a very brief period. As Wilson and Roome<sup>21</sup> have emphasized, the release of a tourniquet which has been in place for some time results in a marked fall in blood pressure, due to fluid loss into the extremity. This is undoubtedly due to vascular injury from anoxemia, and in an extremity already traumatized, the application and release

of a tourniquet further devitalizes tissue, leading to greater plasma loss.

The patient brought in in shock is usually chilled, and should be warmed immediately, warmed blankets being most satisfactory. Hot water bottles and other methods are available, but care must be taken not to burn the patient. Unless head injuries are present, morphine should be given to relieve pain and anxiety,  $\frac{1}{6}$  to  $\frac{1}{4}$  gr. usually being sufficient for the average adult. The use of large doses sufficient to cause respiratory depression should be avoided, particularly if an operation under general anesthesia may be necessary. For the restlessness associated with head injuries, sodium phenobarbital injected intramuscularly may be given cautiously—gr.  $1\frac{1}{2}$  to 3 as necessary.

When these measures have been applied, it will usually be possible to determine the patient's condition both from the blood pressure and general appearance. The patient who appears quite deeply shocked when first brought to the hospital may improve very greatly when warmed and comfortable. However, when the blood pressure remains low, further treatment must be started. Wangenstein<sup>22</sup> has suggested the following limits: A systolic blood pressure of 100 or less indicates potential shock. When the pressure is 90 or less, actual shock is present, and energetic treatment is to be instituted. At the critical level of 70 mm. Hg., inadequate flow of blood is afforded the vital centers, and when continued for several hours, will result fatally, regardless of treatment. Our aim then should be to prevent the continuation of a low blood pressure with its circle of vasoconstriction, tissue anoxia and fluid loss through the small vessels. This can be done by increasing the blood volume. The most satisfactory substance is whole blood transfused by direct or indirect method, after proper typing and cross agglutination tests. The amount to be given will depend upon the circumstances. The average sized donor may give 500 to 750 c.c. of blood without

ill effect, and the patient in moderate shock should receive this amount at once. Patients in severe shock, whether from external or concealed hemorrhage, will need more blood, perhaps requiring several large transfusions. The amount will necessarily depend on the patient's reaction. When the blood pressure has been raised to above 100 mm. Hg., the patient probably has a satisfactory blood flow and blood pressure, but with very little reserve to withstand further trauma, such as operative procedures. When it is feasible, direct transfusion is preferable to indirect.

Gum acacia, 6 per cent in 0.9 per cent saline, was recommended in the treatment of shock in 1917 by Bayliss. Acacia, being colloidal, is held in the blood stream, while crystalloids have only transitory effect due to rapid loss through the vessel walls. A 6 per cent acacia solution in 0.9 per cent saline may be used as a temporary measure in the treatment of shock until blood is available for transfusion. It is probably better not to give more than 500 c.c. of acacia to any one patient because of possible ill effects. Severe and fatal reactions have been reported by Studdiford<sup>23</sup> following its use. A large proportion of the acacia is deposited in the liver in experimental animals, resulting in damage to carbohydrate and serum protein metabolism.<sup>24</sup> Good, Mugrage and Weiskittel<sup>25</sup> have reported satisfactory results with acacia in an average dose of 500 c.c. and not more than 1,200 c.c. Reactions occurred in 10 per cent of the patients. It is our impression that acacia should never be used if blood is available.

In shock due to trauma with resulting injury to many capillaries, solutions of isotonic saline or glucose given intravenously must be used with care. Such solutions raise the blood pressure for only short periods while they stay in the blood stream. Experimental observations<sup>26</sup> have shown that on leaving the vessels, protein is carried out along with the fluid, further decreasing the plasma concentration and volume. These findings have been con-

firmed on patients by Minot and Dodd<sup>27</sup> and by Gatch.<sup>28</sup> It seems quite definite that large volumes of solutions of crystalloids given intravenously in the presence of capillary damage may result in harm.

The patient in shock should not be subjected to surgical procedures other than absolutely necessary ones until the shock has been controlled. The anesthesia, trauma and loss of blood attending operation will further reduce the blood pressure, and jeopardize the patient's chance of recovery. The possible exceptions to this rule are cases in which concealed hemorrhage is suspected, as bleeding into the pericardium from a penetrating wound, rupture of the spleen, liver or kidney or ruptured ectopic pregnancy. In these instances the advantages to be gained in arresting hemorrhage by immediate operation will have to be balanced against the hazards of operating with the patient in shock.

In such cases, where large amounts of free blood may be found at operation, autotransfusion may be used, and may prove lifesaving, particularly if no blood donor is available. The blood is aspirated or may be scooped out with the hands into a sterile container in which 50 c.c. of 2.5 per cent sodium citrate is placed for each 500 c.c. of blood. The citrated blood is then filtered through several layers of gauze to remove clots, and re-infused into the patient's veins. Watson and Watson<sup>29</sup> report that in ectopic pregnancies, from 500 to 1,600 c.c. of blood may be recovered—a valuable amount to be saved for the patient, which may mean the difference between an adequate blood pressure and fatal shock. They recommend autotransfusion for ruptured ectopic pregnancy, injuries of the liver or spleen, and in hemothorax or hemopericardium. The wisdom of using autotransfusion in an injury of the liver is questionable. Lockwood<sup>30</sup> used this method in a splenectomy for Banti's disease, in which 750 c.c. of blood was recovered from the spleen and reinjected into the circulation. Obviously autotransfusion cannot be

used in abdominal injuries where the gastrointestinal tract has been perforated, contaminating any blood in the peritoneal cavity. When blood has been present in the body cavities for some time, hemolysis may occur, leading to reactions. Such blood should not be used, if possible.

The establishment of blood banks in large hospitals should make transfusion much more readily available, but technical problems and the limited time which blood may be stored before hemolysis limit its use to larger hospitals. The same difficulties hold true for the use of placental blood. Regarding the use of preservatives, Scudder, Drew, Corcoran and Bull<sup>31</sup> recently stated, "Of the many preservatives used, none tested prevented the diffusion of potassium from cells. In several hemolysis was slower and in one it did not take place at all, yet the diffusion of potassium was not altered. The remainder showed definite hemolysis; in some it started as early as the fifth day. All this illustrates the inadequacy of present methods of storage."

Preservation of serum by the "lyophile" process<sup>32,33</sup> allows the collection and preservation of human serum without alteration of its characteristics. The experimental results of Bond and Wright<sup>34</sup> and of Mahoney<sup>35</sup> on the use of preserved plasma in shock due to hemorrhage or trauma are very encouraging. Although such plasma lacks the oxygen carrying capacity of whole blood, in many forms of shock, notably in burns, hemoconcentration is present, indicating the need for plasma only. A quickly available source of plasma such as lyophile serum would obviate some of the difficulties of blood transfusion. However, such plasma retains its agglutinins and would require typing. Ravdin<sup>36</sup> states, "The frequency with which reactions have occurred following the injection of lyophile serum given in concentrated or normal form, makes us hesitate to suggest the more general acceptance of this material." Cost of obtaining and preparing preserved plasma will probably limit its use.

The use of ascitic fluid as a blood substitute has been suggested by Davis and White,<sup>37</sup> Choiser and Ramsey<sup>38</sup> and has been used clinically by Davis and Blalock.<sup>39</sup> The latter point out that ascitic fluid is plentiful, cheap and can be kept for long periods without preservations and without deterioration. Its protein content is 2.0 to 3.19 per cent or 28 to 45 per cent of the concentration in blood plasma. Although not ideal, such a protein content should be superior to the use of saline or glucose. The authors' use of ascitic fluid in human cases of shock was limited, but heterologous and homogenous infusions had been given in ten patients, with two hyperpyrexial reactions. Ascitic fluids also contain agglutinins, and must be of the correct blood group.

In hospitals, even though they may be small, it is often possible to have blood donors available by the routine blood typing of convalescent patients who are in good physical condition. Where blood is urgently needed for a patient in shock, these convalescents may be willing to act as donors.

In the prevention and treatment of shock due to burns, tannic acid<sup>40</sup> is of great value. It is debatable whether its greatest benefit consists in a reduction in the loss of plasma, a lessening of the chance of severe infection or a diminution in the absorption of toxins. Bettman<sup>41</sup> has advocated the tannic acid silver nitrate treatment of burns. He points out that in serious burns, 60 per cent of the fatalities occur in the first twenty-four hours, nearly all of these from traumatic shock. The combination of tannic acid and silver nitrate is of superior value, he states, because of the almost immediate stopping of fluid loss from the burned surface. There is a quick cessation of pain, and a minimizing of shock. The danger of infection is lessened by the early drying of the tan. In the use of tannic acid-silver nitrate, the patient receives a narcotic and 5 per cent tannic acid may be applied on cotton swabs or by the use of a spray. With ex-

tensive burns, the patient may be placed in a tub of warm water as advocated by Wells,<sup>42</sup> containing enough tannic acid to give a muddy appearance to the water.

The following is the routine advocated by Blackfield and Goldman:<sup>43</sup> In the tub, all blebs and loose tissue are removed gently by means of sterile forceps and scissors. The surrounding skin is cleaned with green soap and water. The bath is changed as often as is necessary to dispose of the debris. The débridement and cleansing of the burned area usually require sixty to ninety minutes. At the end of this time, the patient is dried with sterile towels. The burned areas are then touched a number of times with gauze soaked in 10 per cent silver nitrate. The patient is placed under a cradle on sterile sheets. Several times a day for the first few days, a 1 per cent aqueous solution of gentian violet is applied to the tanned areas. By this means, small fissures or other areas which might become moist remain dry. If the patient is unable to take fluids by mouth, they should be given parenterally. Glucose 5 per cent in 0.9 per cent saline may be given intravenously. When shock is present, with marked hemoconcentration, transfusion of plasma or whole blood is indicated. The use of large amounts of saline or glucose<sup>26, 27, 28</sup> under these conditions results in the further "washing out" of plasma proteins from the blood stream and is to be avoided. McClure and Allen<sup>44</sup> and Harkins<sup>45</sup> have written excellent reviews on burns.

In secondary traumatic shock in which the blood volume is markedly reduced, the use of vasoconstrictor drugs such as adrenalin and ephedrine is not indicated. A low blood volume is the cause of the low blood pressure, not peripheral dilatation. The use of vasoconstrictors only increases the anoxemia of the body tissues with further loss of fluid from vessels.<sup>7</sup> Similarly digitalis drugs are not indicated, because the heart is not at fault.

The use of oxygen by inhalation has received little attention in the treatment of

shock. Although the oxygen content of the arterial blood is normal, that of the venous blood is greatly decreased. The inhalation of oxygen, increasing its partial pressure in the lung, would result in an increased amount dissolved in the plasma, and an increase in oxygen available to the tissues. The use of oxygen has been suggested by Yandell Henderson,<sup>46</sup> but unfortunately has been but little used clinically. To be effective, oxygen must be given with a nasal catheter or face mask or oxygen tent. Mere blowing of oxygen in the patient's face with a funnel is of little value, since it does not effectively increase the oxygen in the alveolar air. The use of the Boothby mask will simplify and render less expensive the administration of oxygen. It would seem logical to use oxygen inhalations in the treatment of traumatic shock, at least until the blood volume could be restored, carrying the patient over a critical period.

#### CONCLUSIONS

The points which should be emphasized include the following: All instances of shock are not explainable by one theory and such attempts result only in confusion. The most fundamental abnormality in shock is a disproportion in the size of the vascular system and its contents. This may be due to a marked decrease in the blood volume or to an increase in the size of the vascular system or to both. Progress in the prevention of shock has been greater than improvements in methods of treating the fully developed condition. Many of the points to be borne in mind in attempts to prevent shock have been mentioned. If one is allowed to generalize, perhaps the most important point is that an attempt should be made to restore to normal a decline in the blood volume before this is reflected by a significant decline in the blood pressure. This is best accomplished by the use of whole blood or blood serum. A prolonged decrease in the blood volume and blood pressure results in irreparable damage to the tissues and even the repeated trans-

fusion of whole blood may not result in a sustained improvement. The dangers associated with the intravenous injection of excessive quantities of fluid other than blood in the presence of gross capillary damage have been mentioned.

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# MAINTENANCE OF FLUID BALANCE\*

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IN previous discussions of fluid balance<sup>1,2,3</sup> emphasis has always been placed upon individualizing the treatment to fit the needs of the patient, and further experience has more firmly established the soundness of this view. If a patient can take fluids by mouth there is generally no problem concerning the maintenance of a good fluid balance, and much of the material in this article has no bearing on such cases. Unfortunately often in emergency situations, for one reason or another, the patient cannot take fluids by mouth and the proper parenteral therapy is in the hands of the physician.

Emergency surgery commonly involves patients who are well up to the time of an acute trauma, and there are often no long standing deficiencies to deal with. In traumatic injuries, shock is of rather common occurrence and its prevention and treatment have been well discussed in the preceding article by Cressman and Blacklock,<sup>4</sup> who, among other things, point out the dangers of administering large amounts of glucose or saline solutions when shock is present. This will be referred to later, but it here serves well to point out that the administration of fluids in emergency situations requires thought based on facts if one is to select the proper kind and amount of fluid to give.

Considering the kind of fluid to use, the choice is between the saline and glucose solutions, and the important point is that there is possible harm with the use of the saline and practically none with the glucose. The relation of sodium chloride to edema is common knowledge and yet several liters of physiologic saline or

Ringer's solution may be given daily to patients who can ill afford the edema of salt on top of the edema of trauma. Accordingly, a few references to this possible harmful effect of saline solutions are in order.

## SALINE SOLUTIONS

White, Sweet, and Hurwitt<sup>5</sup> studied the water balance of neurosurgical patients in order to be able to maintain them in a slightly dehydrated condition. In their article they state that "edema from too much salt solution is a very real danger. For this reason we recommend limiting the use of glucose in saline to the period of operation, during which there is a considerable loss of sodium chloride. Thereafter, fluids can usually be taken by mouth in adequate volume by neurosurgical patients. Saline solutions should only be used when the serum electrolytes are seriously depleted by prolonged vomiting or diarrhea, and then in limited amounts." In their summary White, Sweet and Hurwitt<sup>5</sup> state: "postoperatively fluid must be replaced much more accurately in neurosurgical than in general surgical patients. While the latter may be given a moderate excess of fluid with impunity, a slightly deficient state of hydration is safer after operations on the brain, in order to minimize cerebral edema. In the absence of vomiting or diarrhea, 5 per cent glucose in distilled water appears to be a better solution for prolonged intravenous administration than when combined with normal saline, because the addition of saline increases the risk of edema." This reasoning holds equally well for patients with cranio-

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cerebral injuries. Temple Fay<sup>6</sup> has long been an ardent supporter of dehydration therapy for such patients.

Beard and Blalock<sup>7</sup> studied the composition of the blood of dogs undergoing continuous trauma to the intestines when no fluid was injected and when fluid was injected continuously. A copious weeping of fluid from the peritoneal surface resulted from the trauma. This fluid had the same protein content as that of the blood plasma, the result being a loss of protein and therefore a diminished osmotic pressure of the blood. The effects of the injection of various fluids on the reduced protein content of the blood of these dogs, which were in shock, is most important. With the continuous injection of 0.9 per cent salt solution there was a decrease in the total volume of blood plasma and a marked reduction in the percentage of protein per unit volume of serum, the calculated entire amount of protein in the blood stream being generally one-half of the original values. It was the impression of Beard and Blalock<sup>7</sup> that if the injection of salt solution was stopped the blood pressure of the animals declined more rapidly than if no fluid had been introduced. With 3.0 and 6.0 per cent saline solution the results were essentially the same. From these experiments there is little to expect from the treatment of shock due to blood plasma loss by the use of physiologic saline solution. Beard and Blalock state "that they do not mean to imply that if a patient is in shock as a result of an injury and no donor is available that saline or similar solutions should not be injected. However, in the absence of a favorable response in blood pressure after a considerable amount of solution had been injected, almost certainly the further administration of the same fluid intravenously would diminish the chances of recovery."

Another warning concerning too much salt solution arises from a study by Jones and Eaton<sup>8</sup> on postoperative nutritional edema. Their thirty-four patients were all seriously ill, chiefly with lesions of the

gastrointestinal tract, producing anorexia and undernutrition. Clinical edema was present in twenty-six of the patients, five had definite edema of the lungs, and eight on whom a gastroenterostomy had been done were considered to have edema of the stomach, of the gastroenterostomy stoma or of the adjacent intestine sufficient to produce partial obstruction at the stoma. Among the several factors thought to be responsible for the edema was the administration of excessive amounts of water and salt.

Jones, Eaton and White<sup>9</sup> then produced edema in cats and considered the factors responsible to be important in the following order: nitrogen starvation, general malnutrition, sepsis, the administration of excessive amounts of water and sodium chloride, serous drainage, major surgical procedures and general anesthesia. Mecray, Barden and Ravdin<sup>10</sup> showed experimentally in dogs that obstruction at the pylorus and at gastroenterostomy stomas could be produced as a result of edema incident to low plasma proteins and that gastric emptying time improved as the proteins increased. Their study emphasized that while edema is clinically an observation of excess fluid in the subcutaneous tissue, it is but an external manifestation of a general process with very definite harmful effect on internal organs.

The ease with which salt solutions are retained by seriously ill surgical patients was further demonstrated by Coller, Dick and Maddock,<sup>1</sup> who provided intravenously about 3500 c.c. of fluid daily to their patients under investigation, using 5 per cent glucose in either physiologic saline or Ringer's solution. At present in their patients selected for study, many seriously ill surgical patients have one or more of the important features setting the background for the retention of water, that is, nitrogen starvation, general malnutrition, sepsis, serous drainage, hemorrhage, impaired hepatic or renal function. But even with these it takes water and sodium ions for the edema to develop,<sup>11,12</sup> and it was the



impression of Collier, Dick and Maddock<sup>1</sup> that an excess of saline solution had been the precipitating factor in patients seen by them with postoperative edema. In their study group, twelve of the thirteen patients receiving salt solution retained water and gained weight although they were receiving insufficient calories and should have lost weight.

This common error of giving excessive amounts of salt solution to seriously ill patients when sodium chloride is not needed, is one to avoid. It is thoughtless as to the requirements of the patient; the excess amount of salt administered may easily amount to from 30 to 50 or more grams which must be excreted by the kidneys; and finally, the edema fluid is known to impair various functions and be harmful. The surgical staff may well feel guilty in some instances when patients come to autopsy with water-logged tissues.

The discussion so far on saline solutions has pointed out their possible harmful effects. However, everyone realizes that saline solutions must be given to some patients, but they are essentially for patients who have or have had abnormal losses of fluids containing sodium chloride. The most serious of these abnormal losses occur through severe diarrhea, dysentery, and vomiting. The first two are uncommon among surgical patients, while vomiting is the most frequent form of losing substantial amounts of body electrolytes. Other losses from the gastrointestinal tract may occur through biliary or intestinal fistulae, and recently there has been added the valuable therapy of continuous gastro-duodenal suction.<sup>13</sup> When appreciable amounts of body electrolytes, chiefly sodium and chloride ions, have been lost through any one of these channels, they must be replaced. Evidences of even moderate deficiency are lethargy, depression, weakness, fatigue, anorexia, nausea, dehydration, drowsiness and stupor. With marked hypochloremia several patients at the University Hospital<sup>14, 15</sup> and elsewhere<sup>16</sup> have shown the complete clinical picture

of shock. The problem is how to restore sodium chloride adequately to these patients without giving too much salt.

At the University Hospital an attempt has been made to keep saline solution therapy on a simple basis, which on repeated studies has been shown to be as accurate as possible and still practical. The problem is divided into two groups, the first covering patients who are in the hospital and while under observation are losing important amounts of electrolytes through vomiting, gastroduodenal suction, intestinal or biliary fistulae, etc. The second group is composed of those patients who lost their sodium chloride before entering the hospital and on admission are found, after blood chemistry studies, to have low chlorides. There is, of course, some overlapping of these groups, since a patient who has been vomiting before admission to the hospital, may continue to vomit while in the hospital, but then the two methods of treatment are simply combined and both used as needed. They can be considered as follows:

Patients losing important amounts of gastrointestinal secretions while in the hospital have these losses measured. This is not difficult. Bile drained from the common duct or gall-bladder through tubes is readily collected in bottles. Suction is applied to intestinal fistulae and the drainage collected in siphon bottles. Patients who vomit more than once or twice have a Levine tube inserted through the nose and gastroduodenal suction started, and the amount of fluid withdrawn is readily measured. Also, the use of this gastro-duodenal suction which has been shown by Wangenstein and his associates<sup>13</sup> to be so effective in intestinal obstruction, is applied to many patients to forestall vomiting or to keep the stomach and intestines decompressed after gastric and intestinal or other operations.

There is thus a frequent need for replacing daily abnormal losses of sodium chloride. Our treatment is based upon the fact that there is less of this salt in the gastro-

intestinal secretions lost than in an equal volume of physiologic saline or Ringer's solution. Data showing the sodium chloride concentrations in the various fluids are presented in Table I, from which it is

TABLE I  
CONCENTRATION OF SODIUM CHLORIDE IN VARIOUS FLUIDS

	Variation in NaCl Concentration Gm/L	Average NaCl Concentration Gm/L	Reference
Vomitus . . . .	1.2-6.2	3.3	Dick, Collier and Maddock <sup>17</sup>
Gastroduodenal drainage (Wangenstein suction).	1.9-7.9	5.7	Bartlett, Bingham, and Pedersen <sup>18</sup> (Analysis of 100 twenty-four-hr. specimens)
Hepatic bile. . . . .	3.5-6.4	5.1	Bartlett, Bingham and Pedersen <sup>18</sup> (Analysis of 30 twenty-four-hr. specimens)
Intestinal fistula drainage.	3.1-6.6 4.7-7.9 3.0-8.8	5.2	Bartlett, Bingham and Pedersen <sup>18</sup>
Diarrheal stools	3-7.5	4.3	Welch et al. <sup>18</sup>
Physiologic saline solution		8.5	Karr and Abbott <sup>19</sup>
Ringer's solution		9.0	Bartlett, Bingham and Pedersen <sup>18</sup>
Ringer's solution		7.0	U.S.P. University of Michigan Hospital Abbott's Laboratories

apparent that if a patient has a liter of gastroduodenal drainage a liter of physiologic saline or Ringer's solution will replace the water and more than the sodium chloride loss by a fair margin. This volume-for-volume rule is the replacement method used at the University Hospital in such cases. In actual performances two other ideas are incorporated into the procedure. The first is that when gastroduodenal suction is being used, a liter of Ringer's solution is given during the first twenty-four hours, in this way lessening an initial drop in plasma chlorides during this period.<sup>14,15</sup> For the second twenty-four hours the amount of Ringer's solution given equals the amount of gastroduodenal drainage for the first day, and this volume-for-volume replacement continues with

the addition of the second idea, which is that a minimum of 500 c.c. of Ringer's solution is given daily, even if the drainage for the preceding day is less than this amount. It has been found for general surgical patients having gastroduodenal tube drainage, biliary and intestinal tube drainage that satisfactory plasma chloride and carbon dioxide combining power levels can be maintained by this seemingly rational procedure.<sup>14,15,20</sup>

For the second group of patients, those with low plasma chlorides when first encountered, the clinical formula<sup>14,15</sup> for restoring sodium chloride is used. This formula states that: for each 100 mg. that the plasma chloride level needs to be raised to reach the normal (560 mg. per cent) the patient should be given 0.5 Gm. salt per kilogram of body weight. Examples of the use of this formula in three hypothetical cases are given in Table II. Studies have

TABLE II  
USE OF CLINICAL FORMULA FOR CORRECTING SODIUM CHLORIDE DEFICIENCY

Wt. of Patient, Kg.	Initial Plasma Chlorides, Mg. per 100 C.c.	Calculation of NaCl Needed, Gm.
60	460	$0.5 \times 60 = 30$
60	410	$1.5 \times 0.5 \times 60 = 45$
60	360	$2.0 \times 0.5 \times 60 = 60$

been continued on the use of this formula in a large series of general surgical patients, determinations being carried out on the plasma chlorides, plasma carbon dioxide combining power, fluid intake and output, urine chloride excretion, gastrointestinal tract and other fluid chloride losses, and changes in the patient's weight. From these studies several facts are apparent. First and most important is that the clinical formula provides enough salt to restore the plasma chlorides to normal. All patients, however, do not handle the provided salt in a normal manner. The best response, which is a prompt return of the plasma

chlorides to normal and an appreciable excretion of chloride in the urine, is obtained by patients who have not been sick very long but who have suffered a recent or acute loss of electrolytes, as through acute intestinal obstruction or a recent period of prolonged vomiting from any cause. The second group of patients with depleted chlorides often fail to have their plasma chlorides return to the expected level, and either excrete some of the salt given or add it to their body with water and gain weight. These patients generally have had a long standing illness associated with sepsis or general malnutrition or any one of the other factors previously mentioned as predisposing to the retention of water. Carcinoma of the gastrointestinal tract is one of the rather common initial lesions among these patients. Repeated case analyses have shown that giving more salt than the formula calculation fails to increase the plasma chloride level materially and simply adds to the retention of water, as often shown later by evident subcutaneous edema and ascites. In the most recent studies<sup>20</sup> it was found to be definitely a mistake to give more salt.

This failure of the plasma chlorides to come up to the level of normal individuals in some instances when disease is present has been noted before. McLean<sup>21</sup> found that the average renal threshold for chlorides in fever was 542 mg. and in diabetes mellitus 512 mg., instead of his average of 562 mg. per 100 c.c. of plasma found for normal individuals. Davidson<sup>22</sup> found that plasma chlorides in burned patients often remain well below normal despite a good daily intake of sodium chloride. The reasons for these alterations are not clear, but in the University Hospital patients<sup>15, 20</sup> it was the rule that if they improved in general and began to eat, then the abnormally retained salt readjusted and the plasma chlorides approached normal. The clinical formula has been found to be usable by the general staff members of the University Hospital, and along with the volume-for-volume rule has sufficed to

provide adequate amounts of salt for patients needing salt and at the same time has avoided the dangers of excess administration.

Besides the failure to recognize that postoperative edema is frequently initiated by too much salt solution, there are two other reasons why in the past the danger from salt solution has not been more apparent. One is that intravenous fluids are often only needed for one or two days and then the patient is able to take water by mouth. If there had been any retention of fluids as a result of the salt solutions, the administration was for too short a time for it to become apparent. The second reason is that patients who do not have the factors predisposing to the retention of water—general malnutrition, sepsis, etc.—do not retain fluids when given salt solution<sup>1</sup> but excrete the salt and a fair volume of urine just as is done within limits by normal individuals.<sup>23</sup> There are many patients not seriously ill who receive fluids parenterally for a day or two, patients whose general condition was good up to the time of the operation and is good after the operation, but who are temporarily upset and need to be given fluids other than by mouth. The excretion of the sodium chloride is an unnecessary load on the kidneys and the salt solution is a poor choice of fluids for these patients. As emphasized, the real danger from salt solution is with the seriously ill patient and facts and ideas on this subject have been presented in previous paragraphs.

In this discussion the need for sodium chloride has been considered in terms of chloride. This works out practically because in surgical patients significant losses of electrolytes generally occur through loss of fluid from the upper part of the gastrointestinal tract. In such instances the loss of chloride ions is generally greater than, and only occasionally equalled by, the loss of sodium ions. Since in correcting a deficiency of these ions the solutions commonly used, physiologic saline or Ringer's solution, have an equal number of both

ions,\* the deficiency of both can be corrected. Gamble<sup>24</sup> has emphasized that with a good supply of available water the kidneys can be depended upon to excrete the less needed ion.

An occasional case is encountered among surgical patients in which the loss of sodium has been appreciably greater than the loss of chloride ions. Two recent examples were, first, in a patient with marked drainage from an ileostomy done because of chronic ulcerative colitis, and secondly, in a patient with prostatism and severe renal damage. In both these patients a solution providing an excess of sodium, Hartmann's<sup>25</sup> sodium lactate, was given. One must be on the watch for, and understand, these less common lesions in surgical practice.

#### WATER AND GLUCOSE

Glucose solutions are valuable because they supply readily available water and carbohydrates. Water comprises 65 per cent of the total body weight and most living organisms are dependent upon a rather frequent ingestion of water to balance up for its daily loss. As in normal individuals these daily losses for surgical patients are mainly for two processes (1) the water used for vaporization from the skin and lungs as part of the heat dissipating mechanism and (2), the water for kidney function. In the operation of these processes it is quite apparent that the heat dissipating mechanism has prior rights over kidney function for available water, the latter using for excretion what is left after the former has taken what it needs. On the surgical services of the University of Michigan Hospital, the staff is encouraged to think of the water requirements, and to order the glucose solution which provides the water on this basis: so many cubic centimeters for vaporization and so many more cubic centimeters for

urine output. The figures to have in mind are arrived at as follows:

Vaporization from the skin and lungs for normal adults in comfortable environmental conditions varies from about 1000 to 1500 c.c. daily,<sup>26</sup> the larger figure being for the larger or more active individuals. These same figures have been found to be true for surgical patients who have no tax upon their heat dissipating mechanism. On the other hand, patients with fever or with hyperthyroidism, or when the environment is hot and humid, have the additional factor of sweating and more water is thus lost by vaporization.<sup>27</sup> Wassel<sup>28</sup> investigated the vaporization loss in patients when the weather was particularly hot and humid and obtained figures from 2,068 to 5,034 c.c. daily. However, for any case complicated by some tax on the heat dissipating mechanism, the vaporization loss can be estimated at 2000 c.c. daily. More will be necessary with the extremes of fever and heat.

The amount of urine put out by the kidneys is a matter over which the physician has some control. Just what is a minimum permissible daily urine output and what is a satisfactory amount? Lashmet and Newburgh<sup>29</sup> have furnished information in this regard by making a comparative study of the excretion of water and solids by normal and abnormal kidneys. From their data Table III was composed and shows the amount of water needed to excrete 35 Gm. of waste material, which is about an average daily amount.

From Table III it can be seen that about 500 c.c. of urine is the very minimum daily amount, and is obtained only when normal kidneys are working at maximum concentrating ability. With volumes appreciably below this amount one may expect retention of waste materials, as shown by an increased blood nonprotein nitrogen. With diseased kidneys more water is needed, until with a concentrating ability down to a specific gravity of 1.014 to 1.010 approximately 1500 c.c. of urine is needed to do what the normal can accomplish with

\* There are a few less sodium ions than chloride ions in Ringer's solution because of the presence of a small amount of KCl and CaCl<sub>2</sub> in that solution.

500 c.c. On the surgical services at the University Hospital it is considered desirable for the more seriously ill patients—those with sepsis, with severe biliary disease, etc., to put out 1500 c.c. of urine per day. For other patients 1000 c.c. is a good volume, since under the conditions of Table III, 1000 c.c. can be seen to cover all but the most seriously diseased kidneys.

TABLE III  
MINIMUM AMOUNT OF WATER NEEDED BY KIDNEYS TO  
EXCRETE 35 GRAMS OF WASTE MATERIALS

Condition of Kidneys as Shown by Maximum Concentrating Ability	Sp. Gr. Urine	Water Needed, C.c.
Normal.	1.032-1.029	473
Diseased*.	1.028-1.025	595
	1.024-1.020	605
	1.019-1.015	850
	1.014-1.010	1439

\* Chronic nephritis, pyelonephritis, renal tuberculosis, etc.

Other opinions have been given as to a satisfactory urine volume. Wangenstein<sup>13</sup> looks for an output of from 700 to 1000 c.c. per day. White, Sweet and Hurwitt<sup>5</sup> consider 800 to 1000 c.c. per day as best for neurosurgical patients. Graham,<sup>30</sup> in discussing the fluid requirements of patients needing surgical procedures for gastric or duodenal ulcer, asks for a urine output of at least 900 c.c. daily.

A summary of the discussion on the volume of water needed daily to maintain a normal water balance is shown in Table IV. The amounts are those generally accepted as suitable throughout the country. Here they are simply broken up so that one can know their component parts and deal with them as conditions demand. If sweating has been profuse, more fluid must be allowed for the vaporizing process or the urine output will be decreased. If there have been abnormal losses, such as by vomiting, saline solutions must be given following the previously discussed methods, or again the urine output will be low. One

should always remember that a satisfactory water balance is shown by a satisfactory urine output, and conversely, a low urine output, particularly of high specific gravity—which means that the kidneys have good functional capacity and are working hard at the job of excreting waste materials in solution—signifies insufficient available water. It is a sign of progress that one

TABLE IV  
DAILY WATER REQUIREMENTS

	Cc.
Uncomplicated Case:	
For vaporization.....	1000-1500
For urine.....	1000
	2000-2500
Complicated Case (sepsis, hyperthyroidism, hot humid weather, etc.)	
For vaporization.....	2000
For urine.....	1000-1500
Abnormal losses (vomitus, etc.).....	
	3000-3500

now sees less of the old phrase "toxic suppression of the kidney function." There are many simpler reasons for no or little urine output and the commonest one is no or little available water.

Glucose solutions are not only valuable because of their ready supply of available water but also because they provide food for energy requirements, and they protect the liver. Also, they prevent ketosis, and studies have shown that 50 Gm. per day is sufficient to accomplish this in the normal adult.<sup>31</sup> Five per cent glucose in distilled water is close to being isotonic. Winslow<sup>32</sup> found that an average of 98 per cent of the glucose was retained by a group of surgical patients given three liters daily at the rate of from 300 to 500 c.c. per hour. This rate easily permits the administration of from 2000 to 3500 c.c. in a few hours, and it should be given during the day, so that the night is left more comfortable for sleeping. Ten per cent glucose is hypertonic to blood and at the University Hospital it seems to be more frequently associated with phlebitis at the site of the injection than is the 5 per cent solution. However Winslow<sup>32</sup> found that 95 per cent of the

glucose in three liters of the 10 per cent solution given at the rate of 300 to 500 c.c. per hour, was retained daily by a group of surgical patients, who thus obtained 93 per cent more carbohydrate than if they had received an equal volume of the 5 per cent solution. The water of the 10 per cent solution appeared to be as readily available for all purposes as that of the 5 per cent solution. In patients needing more than just a moderate supply of carbohydrates, those with liver damage, with severe hyperthyroidism, with malnutrition and cachexia, the 10 per cent solution is particularly valuable. In its use it is important to remember that a slow rate of administration, about 150 to 200 c.c. per hour, provides continuous food and the least amount of glycosuria.

In conclusion one may well express appreciation for the availability and comparative safety of the different solutions on hand for the parenteral administration of water, glucose and salt. In the small as well as in the large hospitals this therapy is serving its purpose to carry the more seriously ill patients over periods of acute crises, and the best results are being obtained by thoughtful consideration of the needs of the individual patient.

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WATER was never prescribed by ancient man *qua* water, but Plain Water, Well Water, Salt Water, Spring Water, and Cake Water, all vie in popularity with Water-from-the-Bird-Pond, Water-from-the Rain-of-the-Heavens, and most potent of all, Water-in-which-the-Phallus-has-been-Washed.

# SEPTICEMIA, INCLUDING ACUTE INFECTIONS OF THE SCALP\*

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THE limitations of this subject are not entirely clear: surgical septicemia is a very broad subject, the surgical and bacteriological principles of which I have discussed in a recent paper.<sup>1</sup> Acute infection of the scalp, while it is of common occurrence, fortunately rarely results in septicemia.

This paper, therefore, will endeavor to discuss briefly the concept of surgical septicemia and the development of various types of scalp infection. It will, then, present three cases which illustrate the common ground of these two somewhat diverse subjects.

By the term, septicemia, one generally means a diseased condition characterized by a sustained or intermittent fever in which bacteria are continuously or intermittently present in the blood stream and may be cultivated repeatedly therefrom by suitable means. This occurs both in medical and in surgical diseases, the latter being distinguished from the former by the fact that the organisms are of the necrotizing or pyogenic type which tend to destroy, and localize in, certain tissues of the body. The lesion does not tend to resolve spontaneously as in medical infections, but cure depends upon the process being evacuated or removed or isolated by suitable operative procedures. These organisms are, roughly, in the order of their frequency: (1) hemolytic streptococcus; (2) hemolytic *Staphylococcus aureus*; (3) nonhemolytic *Staphylococcus aureus*; (4) nonhemolytic streptococcus; (5) *Bacillus coli*; (6) anaerobic nonhemolytic streptococcus; (7) *Staphylococcus albus*; and (8) *Bacillus mucosus capsulatus*.<sup>2</sup> These organisms get into the physiologic interior of the body through

some break in the primary defense of the body, namely, the outer surface covering of skin and mucous membrane or the inner surface covering of mucous membrane.

The staphylococci as a group may get in through an apparently intact skin because of their common habitat on its surface and in the pores draining the sweat and sebaceous glands and in the hair follicles. It is generally believed that they can live for some time in these regions and may multiply in the secretions from these glands and thus produce poisons which injure and destroy the underlying cells, thus breaking through into the deeper tissues.

The streptococci as a group are usually introduced at the time of an injury when the skin or mucous membrane is mechanically broken. Then, the organisms are carried into the deeper tissues as in accidental wounds, uterine instrumentation or dental extractions.

The colon bacillus generally gets in either through the alimentary or urinary tracts while *B. mucosus capsulatus* has a predilection for the alimentary and respiratory tracts.

It is extremely important for the doctor to attempt to cultivate organisms from the blood stream in any case of persistent or intermittent fever. An early knowledge of the causative organism may point to a hidden focus, for we know that certain organisms have a predilection for certain tissues, and in cases of sepsis are generally found in certain places in the body. Conversely, if the lesion is clinically apparent, experience leads one to predict with some degree of certainty which organism will be found in the blood, and its clinical

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behavior may be foreseen to some extent; for example: the hemolytic streptococcus is by far the most common organism in sepsis of otitic origin, infection of tendon sheaths, or in sepsis from a diffuse cellulitis, while the *Staphylococcus aureus* is more commonly associated with sepsis following carbuncles, suppurative parotitis, well-localized abscesses generally, and osteomyelitis. *Bacillus coli* is the common organism in sepsis from peritonitis and from bladder and kidney-pelvis infections. The nonhemolytic streptococcus is most often associated with the grave face and neck infections of dental origin. On the other hand, the hemolytic streptococci and *Staphylococcus aureus* share equally in the incidence of sepsis following severe infections of the kidney parenchyma. *Bacillus coli* and the nonhemolytic streptococci are equally involved and often found together in the liver and peritoneal abscesses, and either or both together are occasionally found in the blood in the later stages of these diseases. The hemolytic streptococcus and the hemolytic *Staphylococcus aureus* share equally in the incidence of vegetative endocarditis.

The frequency of positive blood cultures depends to a large extent on the frequency with which an attempt is made to grow organisms from the blood. Priceless time is often lost before the institution of proper treatment because of the failure to take blood cultures.

It is well known from experimental studies that when bacteria are introduced into the blood stream they are usually rapidly destroyed.<sup>3</sup> Whole blood in the test tube is not a favorable culture medium for most organisms but the circulating blood and the vascular system together are infinitely more efficient in destroying organisms which enter the blood stream. This clearing mechanism is performed by the cellular elements and by certain less easily defined, so-called humoral components in the blood.<sup>4</sup> The cellular elements carry on phagocytosis of bacteria and comprise the polymorphonuclear leuco-

cytes, the macrophages of the blood, the endothelial cells, particularly of the lungs and liver, and the histiocytes of the reticulo-endothelial system. The humoral components include the various immune elements in the blood, natural or acquired, agglutinins, opsonins, bacteriolysins, antitoxins, leucines, plakins, and complement.

Under the most favorable conditions of artificial cultivation, bacteria multiply about once every half hour. Their multiplication within the blood stream must be very much slower than this if, indeed, it takes place at all. The blood makes one complete circuit of the body every minute, passing through the endothelial lined capillaries of the periphery, and the lungs, and possibly the liver also with each round. An organism has to run the gauntlet of phagocytic cells sixty or more times before it has time to multiply. It is extremely unlikely that there is any multiplication of bacteria in the blood stream until the blood has ceased to flow.

When a blood culture is taken from a peripheral vein at the elbow any organism which is recovered has passed the gauntlet of the lung capillaries and the capillaries of the periphery of the forearm or hand. The lungs filter out most of the embolic clots, and the endothelial cells pick up the individual organisms. If an attempt is made to determine the number of organisms per c.c. of the peripheral blood by means of agar pour plates, we find that even extremely sick patients seldom yield more than 100 colonies per c.c. of blood. This is a surprisingly small number if one considers that an ordinary twenty-four-hour broth culture of bacteria has anywhere from 1 to 5 billion organisms per c.c.

The actual number of bacteria which are primarily introduced into the body when the first break occurs in the protective surface, inside or out, is undoubtedly small, but they are frequently associated with some injury of tissue and the presence of foreign bodies. This association often enables the bacteria to survive and colo-

nize. They produce their specific poisons which damage or kill more tissue. Their toxins may attract or they may repel leucocytes. The white blood cells may phagocyte and destroy these organisms or be destroyed by them. Bacteria may be carried by the phagocytes directly into the lymph or blood currents and be filtered out in lymph glands or in the capillaries of the lungs or other organs.

The poisons also damage blood vessels and either cause the blood to clot within the lumen or liquefy their walls. Usually, the thrombi are first formed, then the wall is liquefied and the organisms invade the clot, thus producing a suppurative thrombophlebitis. The same process may go on in lymphatics and in arteries. In the wall of every abscess there are countless thrombosed blood vessels containing infected blood clots with sterile clot propagated peripherally in every one of these vessels. In most cases, this propagation of blood clot comes to a standstill when the abscess spontaneously breaks through the surface or is opened surgically. Not infrequently, however, the propagation of the sterile clot and the subsequent infection of the clot proceeds until it reaches a vessel of large size and a piece of clot either sterile or infected breaks off and is carried by the circulation until it reaches a capillary through which it cannot pass. If bacteria are present in such a clot they may be destroyed by the endothelial cells of the capillaries or they may form a new metastatic colony. This metastasis will be pulmonary, if the infective process is in a systemic vein, hepatic if it is in the portal system, or peripheral, if it is in a systemic artery or on the venous side of the pulmonary vascular system. When metastases occur, the whole process of distribution may be repeated on the venous side of the involved area.

As has been said above, bacteria introduced into the circulation from any primary focus or from any metastatic focus of infection may be destroyed in large

numbers in the blood stream by the clearing mechanism, but if positive blood cultures are repeatedly obtained, we may be sure that the infected focus or foci are distributing organisms faster than the clearing mechanism can take care of them. If this goes on for several days, the whole body may be thoroughly seeded and metastatic abscesses may form anywhere and everywhere, enlarging the vicious circle and sooner or later causing the death of the patient.

In many cases when blood cultures are not taken frequently and in some cases when they are, the results are negative and yet the development of metastases makes it certain that organisms in small numbers at least, have been distributed through the circulating blood. This is particularly true in individuals under 20 years of age who develop an osteomyelitis. The reaction at the portal of entry of the organism may be so trivial as to have escaped attention and the metastatic focus in the bone becomes the distributing focus and is of major importance. Such cases have been explained on the theory that young persons have not developed sufficient resistance to these organisms to produce a reaction at the portal of entry, which would hold the bacteria at this site and not permit them to "invade" or be accidentally carried into the blood stream.<sup>5</sup>

*The responsibility of the surgeon in cases of septicemia is obvious. As soon as a positive blood culture is revealed, it is the bounden duty of the surgeon to find the distributing focus or foci and to approach surgically all of the available foci; either to excise the whole lesion, or establish drainage, or isolate the process by proximal ligation of suppurative thrombosed veins. He is likewise responsible for using every other means at his disposal for destroying the organisms in the focus and in the circulation, for minimizing their further distribution and for building up the resistance of the patient to the infection. These points will be considered below.*

Now, let us consider how these principles apply to acute infections of the scalp with which the forehead and back of the neck should be included. The former, though less hairy, has the same relationship to the skull as the hairy portion and is of variable height when there is any tendency to baldness. The latter is hairy like the integument over the skull and there is no distinct line between the neck and the portion of the scalp overlying the trapezius muscles.

The forehead, furthermore, is subjected to frequent trauma like the dome of the head. The back of the neck and lower part of the scalp proper are alike subjected to superficial irritation and to the development of furuncles and carbuncles, which not infrequently lead to septicemia.

The scalp is highly vascular and this is thought to be a factor in rendering this area less liable to the establishment of a serious infection than other areas similarly injured. Accidental incised or lacerated and contused wounds contaminated with street dirt are frequently sutured by physicians or surgeons without careful débridement or thorough cleansing and yet the development of a serious infection is rare. This fortunate outcome in the majority of cases, however, should in no wise justify the doctor in handling these cases in such a careless fashion, for the early and proper care of such wounds will usually result in healing without any evidence of infection whatsoever. When scalp wounds are associated with a compound fracture of the skull, unless a careful toilet of the wound is effected, the organisms frequently spread deeply and either invade the meninges or the blood stream or both.

Occasionally when brain operations are performed, the scalp wound becomes infected and this is of a much more serious consequence than wound infections elsewhere because the conditions are similar to those of a compound fracture of the skull.

The exposure of the lower part of the scalp and neck to rubbing from a collar often results in filling the pores with dirt

and favors the development of a staphylococcus infection that may reach alarming proportions in a few days. If such lesions are subjected to squeezing or injudicious trauma by the surgeon's knife or if there is undue delay in instituting treatment, the organisms may be freely distributed into the blood stream by dispersion of infected blood clots in the periphery and a real septicemia may follow. This is shown in Case I.

Infections of the forehead and scalp not infrequently result from a direct spread upward from the face originating around the lips and nose, spreading superficially in or under the skin, as illustrated in Case II, or extending along the masseter and temporal muscles from infections in the upper jaw around the teeth.

Metastatic infective foci occasionally develop in the scalp in cases of septicemia. In most of these processes, an underlying bone focus should always be suspected, as Case III indicates.

#### ILLUSTRATIVE CASES

**CASE I.** Seen in consultation in a suburban hospital. An Italian laborer, aged 21 had had a furuncle over the left mastoid region for several days. He asked a barber to nick it for him. Next day, he developed a severe pain in his left chest. That night, he had a chill and a temperature of 103°F. The next day, he consulted a physician. The doctor made a small incision over the mastoid region, but because of an increase of his symptoms, next day the patient was admitted to the hospital.

Physical signs confirmed by an x-ray film of the chest on admission, revealed bronchopneumonia in the left lower lobe and two days later, it involved both lower lobes. A blood culture taken on the day after admission yielded hemolytic *Staphylococcus aureus*. Sulfanilamide was administered on admission, but on the second day was replaced by sulfapyridine. Hot boric acid packs were applied to the carbuncle which continued to advance. On the day the positive blood culture was reported an initial dose of staphylococcus bacteriophage was given and there seemed to be an encouraging fall in temperature, but for two days on the advice of the attending

physician no more phage was given. Instead 100,000 units of staphylococcus antitoxin were given on the first day and 25,000 units on the next. During the afternoon and evening of this day, his temperature steadily mounted.

I was asked to see the patient on the evening of the next day, which was the sixth after admission to the hospital. The man was desperately sick. The carbuncle covered most of the left side of the scalp with numerous small openings giving inadequate drainage. The left eardrum was bulging. Incision released pus from the middle ear. A film of the mastoid showed no involvement. I recommended the readministration of bacteriophage intravenously, the irrigation of the involved area with phage and wide incision if no improvement occurred in twelve hours. This operation was performed next day, but after twenty-four hours of slight improvement, the temperature steadily rose until death on the tenth day after admission. Transfusions and antitoxin were continued as well as sulfapyridine, but naught availed. Post-mortem examination revealed, besides the extensive carbuncle of the scalp, a general bronchopneumonia in both lungs with both pleural spaces obliterated by extensive fresh fibrinous adhesions. Heart, liver, kidneys and mastoid were not involved.

This case illustrates the rapid development of septicemia and bronchopneumonia following trauma to a furuncle of the scalp. It is possible that from the time the patient first applied to a doctor, no treatment would have saved him because of the extensive seeding of his lungs, but his chances of recovery would have been immeasurably increased if there had been an earlier exposure of the carbuncle permitting the better local application of bacteriophage and if there had been no interruption to the intravenous administration of the phage in large doses.

**CASE II.** Seen in consultation in a suburban hospital. A well developed and well nourished lad of 17 developed a boil on his left forearm, which was quickly followed by another on the left side of his face back of the outer angle of the eye and a third on his nose. The first two remained localized, but the third became a carbuncle and spread rapidly over to the cheeks involving both eyelids, up the nose

to the forehead and gradually involved the whole forehead, including the anterior hairy portion of the scalp. Temperature daily reached 104 to 105 degrees with daily chills. Blood culture revealed hemolytic *Staphylococcus aureus*. Cold applications were applied without halting the progress of the infection. On the eighth day of his illness with the patient rapidly becoming worse and the outlook extremely bad, I was called to see him and recommended the rapid administration of increasing doses of doubly potent staphylococcus bacteriophage intravenously and the local injection of phage with a hypodermic needle around the periphery of the lesion in the forehead and scalp and irrigation with phage through a blunt needle in all of the openings on the nose and eyelids. Definite improvement was evident in twenty-four hours and this increased steadily. Blood cultures taken daily became negative after five days. Swelling of the forehead, nose and cheeks subsided rapidly and that of the eyelids more slowly. He was able to leave the hospital on the tenth day after the first administration of the bacteriophage.

This case illustrates the favorable response to potent bacteriophage when administered early and in large doses both intravenously and locally in a situation in which the outcome is usually unfavorable because of the early development of a cavernous sinus thrombosis.

**CASE III.** Treated in the Presbyterian Hospital, New York City. A well developed man of 46 had a huge carbuncle measuring 10 × 15 cm., involving almost the entire back of the neck and lower scalp. It was of five days' duration and there had been repeated chills and high fever. In the center of the carbuncle there were two openings about ½ and 1 cm. in diameter with a bridge of skin separating them. The lesion was more sharply defined on the right margin than on the left where it seemed to be spreading rapidly. The blood culture was negative. The carbuncle yielded pure hemolytic *Staphylococcus aureus*.

The lesion was treated with doubly potent staphylococcus bacteriophage. The central portion could be irrigated with a No. 18 gauge blunt needle on a syringe through the central opening. Phage was also injected around the

periphery on the left with a No. 28 gauge sharp needle. Temperature gradually fell and the lesion became localized. The center rapidly liquefied and on the tenth day a huge mass of slough separated and was removed through the central opening, which had progressively enlarged. The patient left the hospital on the nineteenth day and the wound was entirely healed on the twenty-third day.

A week later the patient was readmitted with a soft painful swelling  $5 \times 2$  cm. in diameter in the scalp high up on the left temporal region. On the day before admission, he had suffered a severe chill. An x-ray film revealed no bony changes. An incision was made over the swelling with the expectation of finding pus. This was carried down through an edematous temporal muscle to the bone but no pus was found. Blood culture was negative but a culture of the edema fluid yielded hemolytic *Staphylococcus aureus*. The wound was irrigated and lightly packed with gauze soaked with bacteriophage. The wound contracted steadily and the patient left the hospital on the fifth day, but the wound did not completely heal—a sinus persisting. Four weeks later another film was taken of the skull and a sequestrum of the outer table was revealed. This was easily removed without disturbing the rest of the bone. When last seen in clinic, the wound was healed except for a small granulating surface. Subsequently another small abscess developed in the left occipital region which was superficial and responded to incision with local instillation of bacteriophage.

This case illustrates a metastatic focus in the skull following a large carbuncle of the neck. This was almost certainly blood-borne even though repeated blood cultures were negative. The subsequent abscess in the occipital region may have been in a smoldering lymph gland draining either the metastasis or the primary lesion.

#### PRINCIPLES OF TREATMENT

As we have said above, and repeat for emphasis here, whenever the surgeon is faced with a problem of septicemia, it is his bounden duty to find the distributing focus and either remove it, drain it, or isolate it by ligating the proximal vein. He must,

likewise, make every effort to destroy the organisms in the focus and in the blood stream so as to minimize the further distribution of the bacteria. In particular, in acute infections of the scalp much can be done by prophylaxis. Recent accidental wounds should be thoroughly debrided, cleansed and either carefully sutured if fresh, or left open if old, and a culture of the debrided tissue should be made to reveal the organisms with which one has to deal. Furuncles of the scalp or face or neck should be treated conservatively with iodine if superficial or with potent bacteriophage through a blunt hypodermic needle if deep, great care being taken to minimize trauma. Active surgical treatment when an acute infection has developed and has resulted in a septicemia, should aim at removing as much of the distributing focus as possible. In very sick patients with carbuncles, particularly in diabetics, excision is often better than more conservative treatment. If the organism is a hemolytic streptococcus, sulfanilamide or sulfapyridine should be given in adequate doses to maintain a blood concentration of 5 to 10 mg. per cent with precautions taken to note any early evidence of toxicity from these drugs. The wound should then be treated daily with a creamy suspension of medicinal grade zinc peroxide (Z.P.O.) in sterile distilled water, care being taken to obtain contact with every part of the infected surface and the dressing sealed to prevent evaporation.

If the organism is a staphylococcus, the organism must be tested for its susceptibility to doubly potent bacteriophage<sup>6</sup> and if it is susceptible, this should be given intravenously in increasing doses—at first every hour starting with 0.25 c.c. diluted ten times in saline and increasing as follows: 0.5 c.c., 1 c.c., 2 c.c., 3 c.c. and 4 c.c. If a reaction occurs with any of these doses, the administration should be stopped for eight hours and then continued every eight hours in gradually increasing doses up to 10 c.c. every eight hours. If no reaction occurs with the initial doses, the

amount may be increased rapidly up to 50 c.c. every eight hours until two successive blood cultures are negative and the temperature is normal. Phage should also be administered freely locally so as to reach every part of the distributing focus if no surgery has been done or every part of the residual infection if surgery has been done. Sulfapyridine should also be tried in staphylococcus infections. Sometimes it seems to be effective and at other times not at all. It does not interfere with the action of bacteriophage.

Potent bacteriophage should be used in *B. coli* septicemia in the same manner as in staphylococcus infections, but it is of no value at present in streptococcus infections.

By "doubly potent" bacteriophage is meant phage which will not only clear (lyse) a broth culture of the organism but one which will prevent a transplant from this cleared culture from growing any colonies on a blood agar plate.<sup>6</sup>

Serotherapy has been disappointing in my experience, but should be tried in staphylococcus septicemia. At present, antitoxins are contained in available sera, but no antibacterial antibodies, although Lyons<sup>7</sup> is hopeful of being able to produce such sera by the use of vaccines made from young encapsulated organisms. Occasionally, with the available commercial serum

given in huge doses up to 250,000 units in conjunction with sulfapyridine, favorable results have recently been reported.<sup>8</sup> Cadham<sup>9</sup> has published some striking figures of recovery in staphylococcus septicemia following the use of "immune" rabbit serum together with normal human serum. Blood transfusions are of value only if there is an indication of loss of red blood cells. This opinion is concurred in by a number of unbiased observers.<sup>2,10,11</sup> We have no evidence that any immune substances are carried over except occasionally in streptococcus infections when the donor's blood is found to have a high opsonic index for the infecting organism.<sup>12</sup>

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# THE TREATMENT OF TRAUMATIC WOUNDS\*

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“THE proper treatment of wounds is to be regarded as the most important requirement for the surgeon” (Billroth). Although this statement was made nearly seventy-five years ago, we believe it is equally applicable in all surgery of today.

We are assuming that those who read this paper have an understanding of (1) the importance of blood supply in the healing of wounds; (2) the dangers of necrosis, débris and blood clots in a wound; (3) the difference between a contaminated and infected wound; (4) what healthy, living tissues can do to combat infection; (5) the value of immobilization in the healing of wounds; (6) the effect the state of health of the wounded person has upon the healing of his wound; (7) the origin of the food which the cells must have in order to grow and heal a wound; (8) the effect of heat and cold upon the proliferating cells; (9) the damaging effects of germicides upon delicate living cells; (10) the damaging effects of tension in a wound; (11) the rationale of moist dressings for a wound; (12) the methods of growing tissue in vitro; (13) the effects of vitamins and various chemical salts upon cell division etc. (see Reid, M. R. *New England J. Med.*, October 22, 1936 and Christopher's *Textbook of Surgery*, 2nd Edition).

A great deal has been written in recent years about wounds and wound healing. One finds it a topic of discussion at almost every meeting of a surgical society and a subject in nearly every issue of a surgical journal. There is an explanation for its deserved popularity. Doctors who encounter considerable difficulty in the

prompt healing of their elective or accidental wounds provide a receptive and appreciative market for such information. Others who have been able to reduce their difficulties to a less alarming degree are only too glad to offer their own remedies.

If one will carefully follow the reports that come from the widespread medical centers of the country, he will be a little disappointed to find a great similarity in all of them. No panacea or new technical trick has been offered. However, on second thought, one should be encouraged rather than discouraged. By comparison one will observe that the underlying trend of uniformity in the articles on the treatment of accidental wounds is due to the widespread approval and acceptance of sound fundamental principles of surgical technique and the incorporation of these ideas in the articles. This is mentioned not for the purpose of criticism, but of praise. When identical thoughts come from so many sources, it means that we must be on the right road. As long as these fundamental principles can be held as standard before the students of surgery then it must be admitted that its institutions are coöperating to train men of high-grade, uniform caliber. It is a great step in advance and its future looks bright.

In spite of all the ideals advanced in a proper surgical technique, it is impossible to escape the personal factor in operators themselves. Every surgeon in his course of work has had the experience of assisting another who knows good principles of surgery, but who does not always apply them. Such an individual will call attention to and do nothing about a poorly shaved

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skin, neglected skin cleansing, small area of skin preparation, tags of tissue strangulated by ligatures, clamps applied with large bites of tissue, tight sutures (Fig. 1), breaks in technique, suturing under tension, closure of a wound in which active bleeding is still in progress, use of heavy suture material when a proper grade could be had for the asking, etc.

Some surgeons will be guilty of these faulty practices only on occasion, while others will let them become a habit. Every surgeon will recall times when he has taken more liberties with his wounds than was his usual custom. And every one will recall instances when he has regretted having taken such liberties. The variables among patients and disease are too great for a doctor to be adding his own technical flexibilities.

It is hardly necessary to call attention to the great physical and economic losses which constantly occur as a result of neglect or improper management of traumatic wounds. Even though one should employ the important fundamentals in handling tissues as mentioned in the preceding discussion, there still remain many pitfalls between the reception of a contaminated wound and its release with uncomplicated healing. Relatively clean wounds usually will heal, even though these fundamental principles of wound healing are not rigidly observed and it is this fact which tends to make many of us careless. Troubles usually begin when contaminated wounds fall into the hands of those who have become somewhat lax in the handling of "clean" wounds. The real test of a surgeon's skill is his ability to treat dirty wounds in such a way that they will heal by first intention. It requires all of the gentleness, thoroughness and patience that one can call forth; but the results are well worth the effort.

It is to be understood that we are for the present limiting "traumatic wounds" to "open traumatic wounds." Our terms must be quite general because they are to include

all types from the simplest laceration to the most severe compound fracture.

If every facility is not at hand to give satisfactory final treatment to the wound, nothing but first aid should be rendered and the patient prepared for transportation to a hospital. Entirely too many foreign bodies, open joint spaces, cut tendons and nerves are being covered by skin suturing in wayside stations. A patient is none the wiser until the infection refuses to subside or function fails to return. The best result of delayed tendon or nerve suture is seldom so good as that obtained by proper care immediately after injury.

There are many ways of controlling hemorrhage in fresh traumatic wounds and some of them should be used with considerable discretion. The blind application of hemostats in a bleeding, unanesthetized wound is not only cruel but frequently harmful. Nerves, tendons, muscles and even intact vessels are often crushed. Clamps dangling from the wound add to the shock, and contaminating materials are mixed with the tissues. For similar reasons the packing of wounds with gauze should be discouraged, although there are times when one must resort to it.

Tourniquets should not be applied in a routine manner. Most wounds will stop bleeding with elevation and the application of large pressure dressings and these measures should be given the first trial. Sometimes tourniquets do not cut off arterial pulsations and merely bring about congestion to promote venous bleeding. They are useful on mangled extremities to check bleeding and to stop absorption of toxins from damaged tissues. In these cases tourniquets are best placed as close to the wound as possible, so that they do not have to be removed before amputation and are not producing useless and harmful ischemia in the part of the extremity that is going to be saved.

Severe cuts of the extremities and all fractures of long bones should be splinted. No antiseptic is to be placed in a wound and no wound irrigation employed if the



patient can be moved to a hospital within six hours. Dirt in a wound during this time will do little harm if the debridement is

adequate and not too long delayed. Dirt particles removed from a wound before the operator sees it may give him the wrong idea about the degree of contamination and thus result in short cut or inadequate measures. Do not attempt to set a compound fracture or even reduce the exposed end of a fragment protruding through a wound. It serves as a plug to protect deeper structures from soiling. Its reduction before operation will add hours to the procedure and may alter the result.

The operator must use his own judgment as to the type of anesthesia. Major wounds, such as those involving nerves, tendons and bones, are usually best repaired under a general anesthetic. Superficial minor wounds are easily handled under local. All debridements requiring considerable dissection should be done under tourniquet whenever possible. A blood pressure cuff is highly satisfactory because it can be released at varying intervals during long operations without disturbing the draperies.

Never start a major debridement without intravenous and transfusion facilities; and never attempt one without adequate and trained assistants. It is not the time to teach a novice who may recognize a gross contamination in a clean set-up but who can't appreciate the difference between clean and dirty areas of a wound undergoing debridement.

If pain is not a factor, the part is prepared before the anesthetic is started. A sterile gauze is placed over the wound, the entire extremity is then washed with soap and water and shaved up to but away from the wound edges. If the injury is near the hand or foot, the part is scrubbed and the nails given the same meticulous care that the operator would give his own hands. The water is removed with alcohol and the alcohol removed with ether. This preparation should be done by the surgeon who has already scrubbed and is in sterile gown and gloves. The tourniquet is then pumped up and the unsterile gauze removed. Any overflow of blood or serum is washed from the skin surface. The surgeon then removes

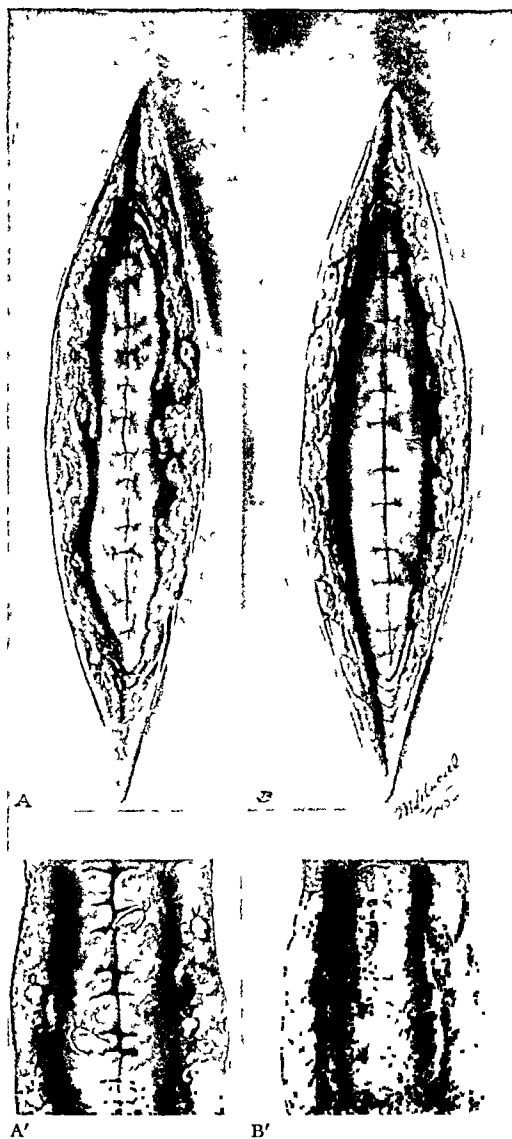


FIG. 1. A and B, rectus incisions made under identical conditions on a dog. In A the fascial sutures were tightly drawn and large tags of tissue were strangulated by ligatures. In B the incision was handled very carefully so that the tissues were not torn. Bleeding was controlled without ligatures and the fascial sutures were made just tight enough to approximate the edges.

A' and B', the same wounds opened for inspection five days later. Neither one was infected, but in A' the tight sutures had produced necrosis and had cut through the fascia. B' showed smooth granulation tissue over its entire surface, but A' still retained tags of slough distal to the ligatures. B' has far greater resistance to infection than A'.

gown and gloves and puts on sterile gloves for draping. Any good skin antiseptic is used freely and over a wide area but never allowed to enter the wound. Plenty of room is given in draping.

Debridements under local anesthesia are difficult because a tourniquet becomes painful to the patient. The purpose of the tourniquet is to save blood and to prevent unnecessary clamping of many bleeding points, which reduces the amount of ligature material in a wound and the time spent to put it there. The tourniquet maintains a clear dry field for the dissection and enables one to avoid soiling of freshly cleansed areas by the overflow of tissue juices and blood, or by frequent sponging of the field with gauze which will so easily touch both clean and dirty areas at the same time and also add unnecessary trauma.

The plan for the debridement at this stage is to use two sets of instruments; one for the actual debridement and one for the necessary surgical repair and closure.

A dry sponge is tucked into the wound. Clamps are applied about the skin edges for traction. An elliptical incision is made through normal skin about  $\frac{1}{4}$  inch from the edge in large wounds. This is carefully developed into the fat but not through it. As the incision approaches the cavity, blood stains are observed in the tissues and its direction is changed. The clean skin flap is undermined as the edge is held up by small retractors. The undermining continues until the subcutaneous fat joins the muscle fascia. If there is doubt as to where this occurs, the clean wound is protected with moist flat gauze, the field protected with towels, the fluff removed from the dirty wound with a clamp and the cavity inspected. Another dry gauze is replaced and the clamp is kept in a separate basin for similar future use. In this manner the entire wound follows the muscle fascia and torn muscle bellies. Long fibers are split with a knife and incisions crossing the fibers are best made with small scissors. Areolar tissue can be followed along

periosteum, vessels, tendons and nerves. Always protect the field and clean wound with towels and moist gauze, so that in case of contamination the protection can be changed or removed, rather than covered over and allowed to remain as another source of unrecognized contamination.

Often the dirty wound can be lifted out without a serious break in technique. Severed tendons and compound fractures give the most trouble. In the latter case the dirty cavity is entered when the broken fragment is encountered. However, there need not be any contamination if one is careful to keep the clean surfaces covered. The soiled specimen is clipped free and discarded. The wound is next lengthened in either longitudinal direction until the end of either fragment can be brought out for further debridement. Soiled periosteum stripped from the bone must be sacrificed. It is at this stage when the delayed washing of a wound is most appreciated. Dirt particles are now visible and there is no guesswork in their removal. With an osteotome or thin chisel, a shaving of cortex is started from the clean portion and carried to the end of the soiled fragment. It is picked off with a clamp and discarded. The entire area of bone denuded of periosteum is cleanly shaved in this manner. The tip of the fragment is cut off with the same instrument or perhaps a saw or bone cutter. It is not advisable to use a rongeur for any part of the work. Its biting edges always pass through soiled surfaces, besides tending to leave partially detached pieces of bone.

When debridement of the fragment is completed, it is covered with gauze and returned to the wound. The end of the other fragment is lifted out and similarly treated. After this is done the extreme depths of the wound are systematically given debridement and the cavity is ready for irrigation. Large quantities of warm, but not hot, saline are used. If the fluid is removed by aspiration, one should never use a tube which has been in contact with intra-abdominal or thoracic pus

because boiling water under ordinary conditions will not kill spores. The wound is gently rubbed with a gloved finger to

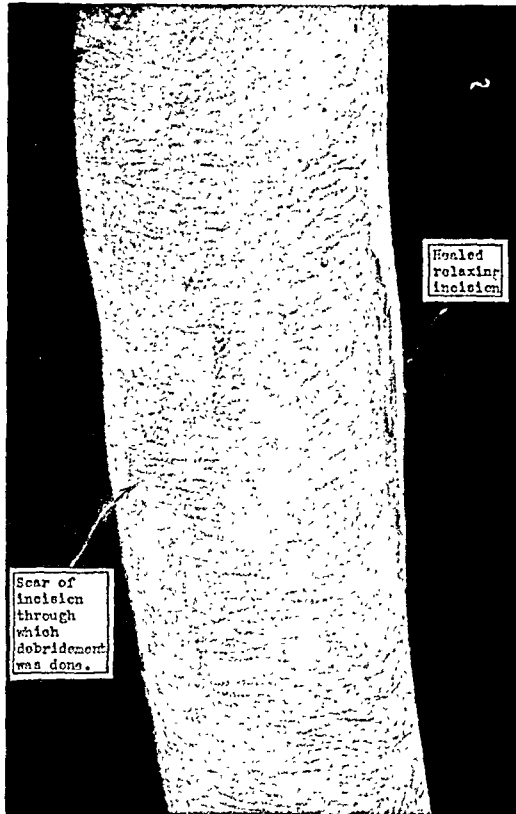


FIG. 2. In an auto accident this patient received, among other injuries, fractures of both bones of the right forearm with the ulnar fracture exposed through a 4 inch laceration. The wound was filled with gravel. There had been no displacement of the fragments so that debridement was essentially that of a soft tissue wound. The swelling caused by the fractures prevented closure of the wound, and a single relaxing incision had to be made. The strip of tissue between incisions was dissected free from the fascia of the muscles and allowed to shift to the ulnar side for suturing. The remaining defect was packed with vaseline gauze and permitted to heal by second intention. This photograph was made three months after the injury. The arm has recovered its full use and the disfiguring scars are ready for excision and accurate closure.

Relaxing incisions must be kept far enough away from the main wound to insure adequate blood supply for the strip of skin to be shifted. Sometimes there is sufficient relaxation without complete detachment of the strip from the underlying muscles. These incisions should be long enough to permit loose closure of the main wound through its length.

detach pieces of loose tissue and blood clots.

During the operation and before removing the tourniquet, any known open vessels are ligated with fine silk. The cavity is again irrigated after the tourniquet has been released. Inspection is then made for ischemic pieces of tissue which are to be trimmed away. Hemostasis is made secure, but this does not imply the use of unnecessary ligatures. At this stage a few moments of waiting and the use of gentle moist gauze pressure will effectively stop many bleeding points.

No mechanical fixation of bone fragments in the wound is employed. Tendons and nerves are sutured with silk. The wound is closed with interrupted sutures of silk in the fascia and skin. If the closure is under tension, and it usually is in fracture cases, counter-incisions are made on either side to give relaxation. (Fig. 2.) These defects may be skin grafted or packed with vaseline gauze and allowed to heal by second intention. Viability of skin over the fracture site depends on a closure without tension; the conversion of a compound fracture to a simple one depends on the skin remaining viable and intact. A moist gauze dressing is applied. The fragments are immobilized by skeletal fixation with pins or by cast alone, depending on the type of fracture; but they must be perfectly immobilized. The patient is given the usual prophylactic dose of tetanus and gas bacillus antisera. The dressing is not disturbed for a week or ten days unless there is an unexplained rise in temperature or abnormal pain.

Let us call attention to the word "debridement" which has been defined as the "excision of a wound." The term has degenerated in its application. Almost any form of wound cleansing has been called debridement and wrongly so. Most doctors know what it means and start such operations with every intention of being thorough. The skin and fat receive fair treatment. Then many of us will begin washing the wounds to take away every bit of the evidence of deep seated dirt. The rest of the procedure will be devoted to aimless picking and clipping of tags of muscle and

fascia over its surface. To be sure, the wound will look clean. One can wash the hematoma and extravasated blood from the muscles of a dressed rabbit which has been shot, but it will still be riddled with bird shot, hair and material from the intestinal tract. The operation doesn't terminate because the work has been systematically completed, but because patience has been exhausted and one doesn't see anything more that can be done. Such a method will work in many cases of superficial, simple incised or lacerated wounds. In fact there is a great deal in its favor for wounds of the face where the blood supply is good, tissues show great resistance to infection and extensive debridements often lead to serious distortions. Elsewhere the method is not reliable and should be discouraged.

T. S., age 24, was admitted to the hospital February 5, 1937 with a compound fracture of the left leg at its middle third. It had resulted from a pile of bricks falling on the extremity.

General examination was not remarkable. The leg presented a laceration 4 inches long at the site of the fracture. There was gross soiling of the wound. No history or evidence of bone protrusion could be obtained although the fractured ends were visible in the wound. Four hours after the accident the patient was operated on under general anesthesia. Debridement was carried out as outlined above. Upon inspecting the bone, gross dirt was found embedded in the periosteum at the point of fracture. It was removed according to the method described. Silk was used throughout. The closure was facilitated by accessory incisions which were later dressed with vaseline gauze. The leg was placed in a padded cast and supported on a knee flexion splint. Gas and tetanus bacilli antisera were given and the patient returned to the ward in good condition.

The temperature curve showed spiking to 101 degrees in the first three postoperative days. It then dropped to normal for one day and spiked again on the fifth, sixth and seventh days. At this time there was evidence of a moderately severe serum rash. The fever and elevated pulse were not accompanied by any increase in respirations. The fever promptly subsided with the rash. All sutures were removed at the end of two weeks when the first

dressing was made. The relaxing incisions were redressed and found to be nearly closed. The patient was discharged to the fracture clinic on February 23 to be treated as if he had a simple fracture.

A time limit of six hours has been placed as an arbitrary dead line for relatively safe debridement of accidental wounds. After six hours the bacteria which formerly were responsible for a state of wound contamination have begun to multiply and to invade the surrounding tissues. Some are of the opinion that it marks the time when contaminating organisms can no longer be washed from the wound surfaces because of their spread to deeper layers by active invasion. This attitude is somewhat misleading since it implies that a contaminated wound can be made sterile by washing. Some of the organisms are removed, it is true, because positive cultures can be made from the washings. However, as a matter of fact many bacteria are probably forced deeper into the tissues. If one will examine a wound after copious irrigation, one will see that the areolar tissue planes and loose structures are bulging with fluid just as though they had been infiltrated with a local anesthetic. The greatest advantage to be derived from wound irrigation is the removal of blood clots, fat droplets and shreds of devitalized tissue, all of which act as foreign bodies in wounds and help to provoke infection when contamination exists.

To cite an example which may aid in clarifying our attitude toward wound irrigation we mention a common story which arises in connection with appendectomy wounds for ruptured appendices. For several years we have closed the peritoneum without drainage in our cases of perforated appendices with peritonitis without localized abscess. The wounds were then thoroughly irrigated with liters of saline and closed. Here should be an ideal case for rendering a wound sterile by washing. The wounds had been made by sharp instruments and every condition provided for primary healing, including a negligible time factor, except for the fa

that pus, carrying virulent organisms, had flowed over its surfaces. Wound abscesses occurred so regularly that it was but a short time until a small rubber drain down to the peritoneum was being left in each case.

A different story is found in laparotomy wounds which can be protected fairly well from procedures of known contamination. Soiling undoubtedly occurs when an open anastomosis is done for ileotransverse colostomy. The abdominal wound is always well protected with heavy laparotomy pads. Observing the same technique in closure, including copious irrigation after peritoneal closure, we have found wound abscess to be the exception rather than the rule.

Tissue susceptibility and type of organism play a part, but the degree of contamination rules the wound. Once more let it be said that this cannot be determined by inspection and one is hopelessly lost by early irrigation of a wound if he plans to do a real debridement. The last case cited brings out the reason why a large dirty wound can be successfully excised and made to heal without infection. The secret is the keeping of a constant vigilance for the protection of freshly excised surfaces by the application of moist flat gauze.

The six hour rule against debridement is not a rigid one and yet the contraindications for operation after that time are not very clear. If smears of tissue juice taken eight or nine hours after injury begin to show large numbers of bacteria, debridement should not be done in case of compound fracture or cases requiring nerve or tendon suture. Debridement is designed to prevent infection. It necessitates the sacrifice of portions of bone, periosteum, nerve, tendon, muscle, fat and skin in order that further loss of tissue, function, time and money may be avoided. When it is certain that infection can only be lessened, then the usual type of wound cleansing may be employed. By the "usual type" we mean the trimming away of skin edges, washing of the wound and removal of tags of devitalized tissue. After

such a wound has healed by secondary intention an elective procedure may be planned for delayed repair of tendons and nerves with silk. Unnecessary loss of portions of these structures by unwise debridement, additional destruction by suppuration about the sutures, coupled with repeated probings along draining sinuses will be prevented.

Debridement has a most important part to play in the treatment of animal and human bites. So far, it has not been widely used, the general trend still being the swabbing and probing of nitric acid or phenol into wounds. Acids are very destructive to tissues and are extremely unreliable in combating contamination. The effectiveness of cauterization cannot be judged by the low incidence of rabies among patients because there is a similarly low incidence of rabies among dogs under observation. Anyone bitten by a truly mad dog should and usually does receive anti-rabic treatment. One cannot definitely say what the effect of debridement would be against the filtrable virus of rabies. If its behavior can be predicted from the observation of other well known viruses, there is no reason why contact with a rabid animal would not permit self inoculation through skin abrasions and mucous membrane surfaces. Excision of the wound can be relied upon at least to prevent infection by secondary organisms.

Human bite infections offer a different problem. The number of tendons, fingers and hands which are lost each year from these accidents must be appalling. The injury is nearly always received in a fight at which time the hand is cut when it strikes the teeth. Usually the injury is over a knuckle and the tendon is exposed or severed. The common methods of treatment are cauterization with acids, wound irrigation and suture. Prophylactic wet dressings are often employed. They are about equally ineffective when the offending tooth resides in an unhygienic mouth. By the second or third day, cellulitis begins and the purulent discharge has the characteristic odor of a lung

abscess or the breath of one who has a mouthful of carious teeth. Its course is familiar to all in that the inflammation will involve the full length of the tendon, neighboring tendons, adjacent joint spaces and often fascial spaces of the hand if drainage is inadequate. The acute inflammation is quickly followed by gangrene which probably accounts for its malignant invasion of adjacent structures.

The initial injury is usually small and the patient is frequently responsible for its early neglect beyond a reasonable hour for preventive surgery. If one is favored by an early call, he has an opportunity for preventing one of the most destructive infections by doing one of the simplest of debridements if he will only take the time to do it.

Thus far we have confined our remarks to the debridement of wounds in general; and, particularly, those wounds whose skin edges can be approximated. It may frequently happen that it is impossible to close a wound by suture following its complete debridement and cleansing. This may occur as a result of loss of skin in the accident or the necessity of cutting away skin which has been devitalized. In such cases much loss of time and trouble may be avoided by the immediate application of a skin graft. As has been stressed especially by Koch and Mason, this is particularly true of wounds of the hands and feet where there is little excess of skin which may be used for closing the wound. As an example of the use of immediate skin grafting in such instances we cite the following case.

R. M., age 47, entered the hospital February 12, 1938 following an injury of the right hand sustained while cranking an automobile. The engine had "kicked," causing the end of the crank to tear through the dorsal surface of the web between the thumb and index finger. The skin and subcutaneous fat were missing. The extensor pollicis longus tendon was exposed, the adductor pollicis muscle was almost completely mangled and there was a compound fracture of the first metacarpal bone at its middle third.

Three hours after the accident, debridement was begun under local anesthesia with the realization that skin grafting would have to be

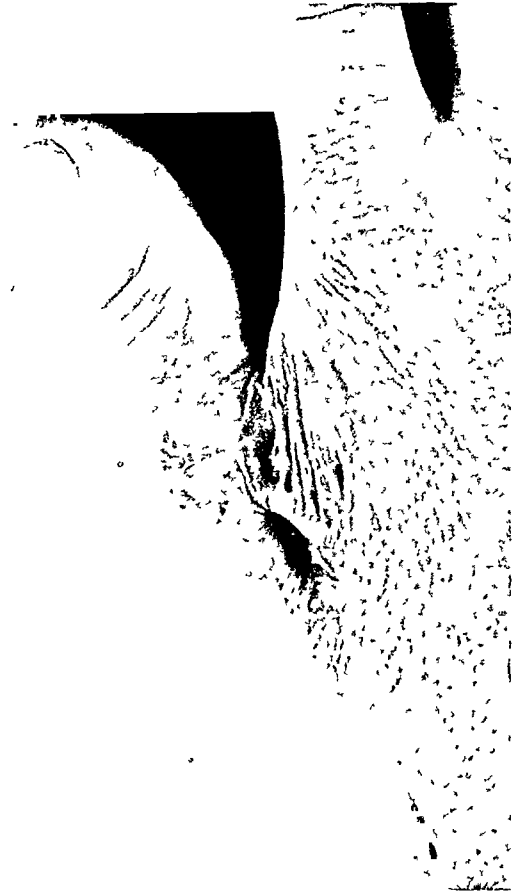


FIG. 3. Primary skin graft to cover a tendon exposed through loss of overlying tissues by injury. See report of case.

done in order to close the defect. However, a bridge of extensor pollicis longus tendon across the wound had not been anticipated. It would have been better to have covered the wound with a flap of skin and subcutaneous fat from the abdominal wall. However, the patient could not stay in the hospital and to simplify his care a split graft was removed from the thigh to cover the defect. Six weeks later he returned to his job as pressman in a print shop.

The photograph, Figure 3, shows a very superficial position of the tendon. Although the graft is adherent to it, there is enough freedom in movement in other tissues beneath the graft to give the thumb a full range of function. It is doubtful whether this tendon would have survived any delayed form of grafting. The patient still refuses further correction.

# THE PREVENTION AND TREATMENT OF TETANUS\*

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THE American medical profession has been amazingly slow to realize that the prevention of tetanus can be effectively accomplished by active immunization against the disease. The great majority of practitioners wait until a suspicious injury occurs, and then give a prophylactic injection of antitoxin. Their failure permanently to protect their patients from tetanus by the use of toxoid comes either from ignorance of its existence, or from misgivings as to its efficacy. The purpose of this paper is twofold: first, to present briefly some of the facts that are known about tetanus toxoid, and second, to consider the treatment of tetanus in the light of recent experimental work.

Before passing on to these two subjects a few comments on the prophylactic use of antitoxin may be in order. It is known that following the administration of 1500 units of tetanus antitoxin the recipient's serum has from 0.1 to 0.25 of a unit of antitoxin per c.c. This titer is maintained for only a few days (four to eleven); consequently, in extensive injuries, or whenever an operative procedure is attempted, a week or longer after the injury, it is advisable to repeat the dose of antitoxin. Experience has shown that in those few instances in which the prophylactic injection has failed to protect the patient from developing the disease, the injection does, however, ameliorate the severity of the symptoms and lowers the mortality. A common error in the use of antitoxin for preventive purposes is to grade the dosage in proportion to the patient's age. Obviously, the wound of an infant may elaborate as much tetanus toxin as the wound of an adult. An antitoxin is given to neutralize this toxin, and con-

sequently the patient's age has no bearing on the quantity needed.

To give or not to give tetanus antitoxin prophylactically is one of the most perplexing questions that haunts the practice of every conscientious doctor. There are no tests or laboratory aids to help solve this problem. Furthermore, severe untoward effects of repeated injection of foreign proteins are increasingly frequent. In fact, serum sickness of a severe grade can occur after an injection of 1500 units of antitoxin, even when the ophthalmologic and skin tests are negative. Because of the hazards incident to inoculations of antitoxin and because it is impossible to give a prophylactic injection after very slight injury, it is extremely desirable that a substitute be found for tetanus antitoxin. Such a substance has been found in toxoid.

The first work with tetanus toxoid was done by Ramon<sup>1</sup> of the Pasteur Institute nine years ago. The interest of the French immunologists in the substance has been sustained. Their experience with it has grown rapidly, for not only has every French soldier been given tetanus toxoid but also all of the horses of the French army. It is important to note that in the past from forty to sixty horses in this group died every year from lockjaw. Last year, however, not a single such death occurred in the 60,000 horses that had been actively immunized with toxoid. In this country there has been a reluctance to rely upon toxoid, largely because of the early reports which seemed to indicate that a small percentage of the population are refractory to it. The latest workers, using an improved technique, fail to find any individuals who do not respond satisfac-

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torily after a properly given course of injections. A large amount of experimental work has been and is being done with toxoid. Sufficient data have been accumulated to justify its widespread use. A brief summary of our present knowledge follows:

**Dosage.** The purified alum precipitate is more efficacious than plain toxoid. An effective immunity can be obtained after three subcutaneous injections of 1.0 c.c. of toxoid, given at six to twelve week intervals. The first injection causes no detectable production of antitoxin but is essential to prepare the patient for subsequent injections. By two weeks after the second injection nearly all individuals show a concentration of antitoxin in their blood, which is supposed to afford adequate protection; that is, at least 0.1 of a unit of antitoxin per c.c. of serum. In a recent study by Gold only one person out of 200 failed to have this desired amount within two weeks after the second inoculation. A third subcutaneous injection of 1 c.c. of toxoid is certain to raise the titer of antitoxin in the serum well above the protective level. This level is maintained for a period varying from three months to two years.

*The most important feature of active immunization by tetanus toxoid is that once a patient has had the three subcutaneous injections, at properly spaced intervals, he is apparently prepared so that at any subsequent time, a fourth injection will rapidly raise the titer of antitoxin in his serum to a level which is absolutely capable of protecting him from tetanus.* This ability of the patient to respond quickly to a fourth injection is known to exist at least five years after the preparatory course was given. It is likely that it exists throughout the life of the patient, but one cannot be certain of this point. Furthermore, the response to the fourth or to subsequent inoculations is so prompt that no antitoxin need be given. Indeed, it seems likely in most individuals, the response to the third injection is sufficiently quick to afford adequate protection from an injury received at the time of

injection, but one cannot take chances with this disease, and for the present it is necessary to insist that active immunity cannot be relied upon until one week has elapsed after the third subcutaneous injection of toxoid.

**Reactions.** Inasmuch as purified alum-precipitated tetanus toxoid contains no serum, it evokes no allergic reactions. Gold<sup>2</sup> has treated allergic patients as well as normal ones, and in over 1000 injections has had only one systemic reaction (hives). Cooke has reported one instance of asthma coming on after an injection of toxoid, but one cannot be certain that this was not simply a coincidence.

It is well known that diphtheria toxoid is poorly tolerated by many adults, but this is not the case with tetanus toxoid. Aside from a slight induration and soreness at the site of inoculation no undesirable effects are recorded.

**Improved Technic of Administration.** Dr. Herman Gold of Chester, Pennsylvania has developed a most helpful improvement in the technique of administering toxoid. He has shown that after two subcutaneous injections a person will respond to *intra-nasal instillations* of toxoid just as promptly as to additional subcutaneous injections. His paper is in the process of publication, but he has been kind enough to give the writer access to his data. From Gold's work it seems certain that after a basal active immunity has been established by two subcutaneous injections of toxoid, the titer of antitoxin in the patient's serum can be raised just as effectively by intranasal instillations of toxoid, as it can by further injections. He has replaced the third subcutaneous inoculation by two injections into each nostril of about 0.1 c.c. of topagen.\* The nose need not be prepared and the instillation can be carried out in the presence of an upper respiratory infection. It should be repeated successively for two or three days.

\*Topagen is a suspension in glycerin of a highly purified and concentrated toxin. It is prepared by Sharp and Dohme.



*Indications for Use of Toxoid.* Although the data available at the moment may be insufficient to warrant the universal use of toxoid, it is likely that within a short time such data will be available. The present European war will afford a crucial test of its efficacy. Some experimental work suggests that the level of antitoxin in the blood is not the only factor concerned in immunity against tetanus, and it may be that subsequent study will show that actively immunized individuals with less than 0.1 unit of antitoxin per c.c. of serum are actually protected against the disease. For the present it seems wise to urge the development of an active immunity in certain groups of people who are unduly exposed to the risk of tetanus. These groups include farmers, children, the military forces, and some industrial workers. For these individuals who are constantly exposed to the infection we suggest the following schedule:

1. Preparatory inoculation of 1.0 c.c. alum precipitated toxoid subcutaneously.
2. From six weeks to three months later a second similar inoculation.
3. Six weeks later 0.1 c.c. topagen in each nostril for two days.

One week after this treatment the individual will have an effective active immunity which will last for a period of three months to many years. Thereafter one can either give topagen intranasally after every suspicious injury, or one can maintain an effective titer in the serum by repeating the intranasal topagen every three months. In infants it is advisable to give tetanus toxoid along with diphtheria toxoid. Experiments are being carried out to see if it is possible to substitute the intranasal instillations for the preparatory subcutaneous injections, but at present there are no data to justify this change.

#### THE TREATMENT OF TETANUS

In view of recent experimental work it seems that the treatment of this disease is on a more rational basis than formerly. The present conception of the pathogeny

of tetanus can be summarized as follows: The toxin formed by *Clostridium tetani* is absorbed by lymphatic and venous channels, and thereby reaches the motor end organs and the motor cells in the spinal cord and medulla. There is no conclusive evidence that the toxin passes up the peripheral nerves. The stiffness and rigidity that occur in a case of local tetanus are due to the action of the toxin on the motor end organs. The clonic convulsions of tetanus are due to the poisoning of the anterior horn cells. It is possible experimentally to produce each of these forms of the disease separately.<sup>3,4</sup> It has been shown that after tetanus toxin teaches the anterior horn cells it becomes fixed (i.e., unrecoverable), and that following this there is an incubation period before symptoms occur. It seems clear that during this period the toxin becomes altered in such a way that it is no longer neutralized by antitoxin and that this altered toxin is the common cause of death in cases of tetanus. Occasionally patients die from the fixation of the muscles of respiration or from spasm of the pharyngeal muscles.

As a consequence of this conception the following treatment of clinical tetanus is suggested:

1. An initial intravenous dose of 50,000 units of antitetanic serum.
2. Infiltration by multiple injections of 10,000 units of antitetanic serum around the site of injury.
3. An hour after this local injection the offending wound should be excised.
4. Daily injections of 5,000 units of antitoxin.
5. Sufficient fluids, preferably by mouth or through a nasal tube, to keep the patient in fluid balance.
6. Adequate nourishment.
7. Control of convulsive seizures by the use of paraldehyde, chloral, or ether-oil (per rectum).
8. The use of a respirator when necessary.
9. Tracheotomy, if there is laryngeal spasm causing suffocation.

A few words of explanation about certain of these suggestions are necessary. The initial dose of antitetanic serum is aimed at neutralizing the toxin that is circulating in the blood stream and also that portion of toxin in the cord which has been fixed but not yet altered. Obviously, it is mere guesswork as to how much toxin there is in the blood of any patient, but 50,000 units of antitoxin are probably sufficient to counteract the circulating toxin in every case. It seems unnecessary to give enormous doses of antitoxin, for it has been shown experimentally that if one full lethal dose has been altered in the spinal cord, a million neutralizing doses of antitoxin do not save the animal.<sup>5</sup> It is emphasized, however, that no one can tell whether or not the symptoms of central intoxication are due to a fraction of a lethal dose or to several such doses; therefore it is imperative to give a fairly large initial intravenous dose of antitoxin.

The second recommendation, namely, the infiltration of antitoxin around the causative wound an hour before excision, is important because it effectively prevents the escape of toxin into the surrounding tissues. A case of local tetanus developing after the neglect of this precaution has been described.<sup>6</sup>

The daily injection of 5,000 units of antitoxin is done to maintain the titer in the blood stream and thereby to insure the neutralization of any additional molecules of toxin that may enter it.

The suggestion that the convulsions be controlled by the use of paraldehyde, choral, or ether-oil (per rectum) is based largely on experimental work with dogs. For this species it seems clear that barbiturates and avertin shorten the animal's life if they are given in sufficient quantity to prevent convulsions. The animals used as controls in this experiment were not given any sedatives and survived almost three times as long as those treated with avertin or amytal. The explanation for this observation is that these substances are

respiratory depressants. Recently a 9 year old girl was brought to the hospital showing signs of a severe tetanus. The pediatricians who treated the patient were pleased with the effectiveness of paraldehyde (from 8 to 20 c.c. p.r.q. 3 h.), and were surprised at the child's recovery.

The use of a respirator in severe cases of tetanus is certainly indicated. The writer has not had opportunity to try out this device clinically, but, on theoretical grounds, it should be of real value in combating respiratory failures. There are certain instances of clinical tetanus in which death is due to spasm of the laryngeal muscles. In one such case a tracheotomy was performed and artificial respiration employed to revive the patient who ultimately recovered.

There are certain therapeutic measures which we do not recommend: first, the intrathecal injection of antitoxin. Experimentally, we have been unable to demonstrate any superiority of this form of therapy over the intravenous route. Similarly the use of magnesium sulfate does not seem justified. The use of phenol intramuscularly has not been tested in our laboratory, but McClintock and Hutchings<sup>7</sup> were unable to find any beneficial effects whatsoever. We have had no experience with oxygen inhalation therapy in general tetanus, but we have tested experimentally the subcutaneous injection of oxygen for the treatment of local tetanus. This procedure did not alter the degree or the duration of the rigidity.

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# THE CHOICE AND USE OF ANTISEPTICS, INSTRUMENTS, SUTURE MATERIALS, DRAINS, AND DRESSINGS IN EMERGENCY SURGERY

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## GENERAL CONSIDERATIONS

THE paragraphs that follow are a discussion of various material aids useful in emergency surgery. For our purposes, "emergency surgery" means operations of immediate necessity for traumatic accidents or for suddenly occurring diseases of intrinsic origin conducted in the operating room of a hospital. We here exclude discussion of surgery in mobile field hospitals in wartime or of first aid surgery undertaken in improvised and adverse surroundings.

In general, large hospitals are usually better equipped and more adequately staffed than are small hospitals. With this advantage they are better able to handle emergency surgical operations as part of their routine every day procedure. Small hospitals, lacking as they often do some of the above advantages in material and staff, should be particularly careful to equip their operating rooms with readily available material supplies fundamentally necessary for emergency surgery. Among such necessities are a good operating room light, a safe anesthesia apparatus, a reasonably modern operating table, a small but carefully selected nucleus of best quality instruments, suture material, drains, sponges, linen, gloves, and adequate apparatus for sterilization. It is furthermore an obligation of every general surgeon who does his work in one or more small hospitals to know thoroughly the quality and extent of emergency material available in those hospitals, and to have a small supplemental kit of his own. The latter is especially useful in cases where he is called to a strange hospital. To whatever extent quantity and variety of material aids may have

to be curtailed, quality and dependability never should be, for emergency surgery often tests to the limit the ingenuity and ability of all concerned. Never, moreover, should lack of equipment be an excuse either for compromising or abandoning ideal methods of surgical technic. Never should emergency surgery, even that of minor injuries, be thought or spoken of as *minor surgery*.

## ANTISEPTICS

A consideration of antiseptics useful in emergency surgery involves their relation to three things: the hands and arms of the surgeon and his assistants, the skin of the patient, and the instruments and other materials used. In all three instances one cannot stress too strongly the necessity and virtues of thorough cleansing and rinsing with soap and water as a preliminary to the use of any antiseptic.

*Hands and Arms.* For the hands and arms after scrubbing, 70 per cent alcohol offers the best combination of availability, lack of irritation and antiseptic qualities. It is best applied with a saturated sterile gauze sponge. In this way a relatively small amount of alcohol may be kept in contact with the hands and arms for several minutes. If a stronger antiseptic for hands and arms is desired, the use of lime and soda after scrubbing is recommended.

*Skin Sterilization.* With the single exception of its irritant qualities, tincture of iodine, preferably in  $3\frac{1}{2}$  per cent solution, remains the most widely available, inexpensive and dependable solution for sterilizing the field of operation or the edges of a wound. There are also various proprietary preparations of high bactericidal power and with lower irritating properties

than iodine. If one of these is locally available at a reasonable cost, its use as an alternate is certainly not contraindicated. Whatever skin antiseptic is chosen should be used either in alcoholic or alcohol-acetone solution. Great care should be exercised with any antiseptic agent to see that it does not enter freely the cavities of wounds and devitalize living subcutaneous cells. Clean wounds do not need irrigation with antiseptics. If they are contaminated, careful débridement and thorough irrigation with sterile salt solution should suffice. If they are infected, antiseptics in as strong concentrations as are necessary for skin sterilization offer little to assist adequate drainage and the use of Dakin's solution or dichloramine-T.

*Instrument Sterilization.* For sterilizing or keeping sterile gloves and instruments various antiseptic solutions, especially carbolic acid and bichloride of mercury, have the same fields of usefulness for emergency operations as in surgery of election. Two very useful concentrations are: carbolic 1:20 and bichloride of mercury 1:3000. When there is a decidedly restricted supply of sterile drapes, the use of a 5 per cent carbolic solution in a sterile basin is a practical and safe expedient for temporary placing of sterilized instruments. Such solutions of antiseptics are also necessary for the sterilization of non-boilable catgut and of certain types of instruments.

#### INSTRUMENTS IN EMERGENCY SURGERY

If a hospital is fortunate enough to have a sufficient quantity of various instruments, it is a great saving of time and confusion to have one complete or nearly complete set segregated in a tray and ready for immediate sterilization at any time. If this is not possible, the list of a "standard emergency set" should be framed where it can easily be consulted at any time. There really should be two lists, one for abdominal operations and one for traumatic surgery, though the number and variety of instruments in each set need not be great. Emergency operations are good

opportunities to practice restraint in the number of different instruments used. It is well to remember that Halsted, our greatest American teacher of the lasting fundamentals of surgical technique, used relatively few types of instruments but insisted on the finest quality and a design calculated to minimize trauma to tissues by permitting gentle and delicate use. Realizing that no single list will satisfy all variations of taste and habit, we nevertheless submit the following as having proved useful in a large surgical clinic over a period of many years.

#### *Instruments for Emergency Laparotomies*

1. *Scalpels.* Two handles and three or four detachable blades of a single medium size.

2. *Towel Clips.* Six of these will be found the most useful number. One can do with four, and in their absence sterile drapes can always be stitched temporarily to skin or to wound edges.

3. *Thumb Forceps.* One or two of the medium sized mouse-tooth type. The teeth should be of the  $\frac{3}{2}$  type and not too long. Another pair without teeth is a useful addition. Lack of teeth, however, does not greatly lessen the amount of trauma done by thumb forceps, certainly as concerns crushing.

4. *Scissors.* Two pairs of Mayo  $6\frac{3}{4}$  inch dissecting scissors, one with straight and the other with curved blades, are enough for all ordinary purposes. The two most useful supplements to these are a pair of special, short, suture-cutting scissors and a pair of long, heavy, curved scissors for use in deep cavities such as the pelvis.

5. *Retractors.* Although Lord Moynihan's dictum<sup>1</sup> still holds, that the hand of an intelligent assistant, gently used, is the best retractor, it is a mistake to handicap oneself by trying to do wholly without instruments for this purpose. Two broad, deep abdominal retractors, either of the rigid or of the flat malleable type, for use with heavily muscled or obese patients, and two smaller, shallower retractors are

about the minimum requirement. In hospitals where the surgeon's assistance is limited to one person, the addition of a self-retaining abdominal retractor to a surgical kit is almost a necessity. In that case, the large retractors, previously mentioned, may be dispensed with.

6. *Hemostats*. If one is willing to exercise some patience in clamping and ligating bleeding vessels a few at a time, no great number of hemostats is needed for emergency operations. At least two types, however, are necessary. The first is a small, straight-bladed clamp  $5\frac{1}{2}$  inches in length and with fine points. It can and should be used for hemostasis in all situations where it is not necessary to seize more than the cut vessel itself and the minimum of surrounding tissue. In situations where larger bites of tissue must be taken and firmly held, a larger, longer clamp  $6\frac{1}{2}$  inches long and with heavier, longer, 2-inch slightly curved blades is necessary. Eight of each kind will ordinarily suffice. Where cost and bulk of equipment are not prime considerations, a dozen of each establishes a useful reserve. In addition it is essential that there be at least two, and preferably four, longer  $8\frac{1}{2}$  inch clamps with curved blades for the control of bleeding from such areas as the splenic pedicle or the depths of the pelvis. Clamps with mouse-tooth ends to their blades cause unnecessary trauma to tissues and should not be used.

7. *Needles*. For suturing skin edges one of several types of straight needle, 2 to 3 inches in length, with either a round, a flat-cutting or a triangular-cutting cross section at its tip, may be selected and kept in stock. The various forms of dermal suture material with swedged-on needles, put up in boilable or presterilized sealed glass tubes, are also useful and handy. For tissues other than skin edges at least one-half dozen each of four kinds of curved needles should be in the emergency kit. The largest of these are half-curved cutting edge needles for inserting tension or stay sutures. Next, there should be three each of similar sizes of full-curved needles of

round, non-cutting cross-section. Finally, there should be one-half dozen fine, non-cutting, full-curved  $\frac{1}{2}$  inch needles with split eyes, for use in intestinal and other delicate suturing. Additional helps for intestinal suture are straight or curved needles swedged on sterilized catgut and ordinary sewing needles, threaded with short lengths of fine silk. This suggested supply of two dozen or more needles for emergency surgery may seem an extravagant luxury, but needles are neither expensive nor bulky, and are often the most neglected feature of emergency equipment. Of all instruments, moreover, they are the most easily broken, lost and dropped.

8. *Needle Holders*. Two standard  $6\frac{1}{2}$  inch needle holders and one longer 8 inch holder for deep wounds are sufficient.

9. *Tenaculum Forceps*. Of these, two three-toothed vulsellum forceps are enough, and much more useful than the Allis forceps usually included. The omission of Allis forceps, furthermore, relieves one of the temptation to seize intestines with them.

10. *Suction Apparatus*. A blunt suction-tip and sufficient heavy rubber tubing are essential parts of emergency equipment wherever built-in or portable suction apparatus is available.

11. *Intestinal Clamps*. Of these there are almost infinite varieties. Most useful are (1) the Rankin<sup>2</sup> three-bladed clamp; (2) the Payr<sup>3</sup>-type crushing clamp; and (3) the Furniss<sup>4</sup> clamp, either in its original form or the smaller McClure<sup>5</sup> modification.

12. *Miscellaneous Instruments*. Here again we could make a long list, but only six items need be mentioned as essentials. These are: (1) a trocar and cannula; (2) a blunt dissector; (3) a grooved director; (4) a uterine probe; (5) a gallstone scoop; (6) gallstone forceps.

#### *Instruments for Emergency Treatment of Accidental Wounds*

1. *Scalpels*. A detachable-blade scalpel handle of small size, with both curved and bayonet blades, is the most useful.

2. *Towel Clips.* Should be of small size. Four usually suffice.

3. *Thumb Forceps.* One pair of medium size and one pair of small size with fine teeth. One or two very fine, one- or two-toothed steel hooks are extremely useful at times, instead of thumb forceps, for gentle handling of delicate skin edges or deeper structures.

4. *Retractors.* One pair of small blunt rake retractors for wound edges. One self-retaining (mastoid) retractor for use where assistance is lacking.

5. *Scissors.* One pair each of  $5\frac{1}{2}$  inch curved and straight Mayo dissecting scissors and one pair of small sharp-pointed ophthalmologic scissors should be provided.

6. *Hemostats.* One-half dozen small straight  $5\frac{1}{2}$  inch (Halsted) clamps and one-half dozen even smaller, finer 5 inch "mosquito" clamps with  $\frac{3}{4}$  inch blades.

7. *Needles and Holders.* Four small fine full-curved cutting needles. Four split-eye, non-cutting needles of same size. Small straight needles of suitable size for skin closure and also for vessel suture should be included.

8. *Miscellaneous Instruments.* Several Allis clamps are useful as adjuncts to retractors. There should also be one probe and one small grooved director and a blunt dissector in the set for traumatic emergencies. There should be at least four bone instruments: a Gigli saw, a rongeur forceps, a sharp curette, and a periosteal elevator, each of medium to small size. An irrigation can with tubing and a fine nozzle is an almost indispensable adjunct to the traumatic emergency kit.

#### SUTURES AND LIGATURES

Indications for or against the use of one or another type of suture or ligature material are very much the same in emergency surgery as they are in surgery of election. The question admits of discussion from many angles but for the purposes of this brief article may best be considered in

terms of the three ways in which sutures and ligatures can be used. They can be buried in the tissues with no intention of removal. They can be used to approximate the edges of wounds. They can be used as temporary tension sutures.

1. *Buried Suture Material.* Silk is mentioned first, not because it should necessarily be used, but because its use should always be considered and favored before deciding to use absorbable sutures. Where the entire operation can be conducted in a "clean" field, silk is the suture material of choice, either in its common twist form or in its braided form. Where the field of operation can be rendered clean, as in the débridement within six hours of a lacerated wound, silk sutures and ligatures again interfere less with satisfactory healing than does catgut. The weight of silk used should be the finest that can be tied without too frequent breaking. It should be of a quality that can be boiled for at least twenty minutes immediately before operation without affecting its tensile strength. Recent developments in the manufacture of very strong yet very fine pliable steel wire offer another type of non-absorbable suture that does not supplant silk but which may sometimes be useful.

Where emergency surgery must be conducted in an obviously infected or seriously contaminated field, it is best to use absorbable suture material. Catgut has long been offered to the profession in a bewildering assortment of sizes and types of preparation. It would not be helpful here to endeavor justly to "choose sides" between these types. Instead, a few considerations will be offered that are sometimes overlooked or discarded in the hurry of preparation for emergency surgery. First, it is reasonable to assume that firms who have been preparing surgical catgut for a period of years are conscientious in their efforts toward perfect sterilization and honest in their advertised claims. One cannot, however, place equal confidence in claims as to rate of absorption. Second, it is well to remember that,

granted sterility in both cases, catgut treated to withstand digestion will be absorbed by the contiguous tissues with far less reaction, though more slowly, than untreated catgut. Third, it is a fallacy to assume that one is "playing safe" by using heavier catgut in emergency operations than one would ordinarily use. The 000, 00 and 0 should be the grades of choice, with occasional resort to No. 1 grade. Fourth, it is well to have in the emergency kit a supply both of boilable and non-boilable catgut.

2. *Skin Sutures.* For the approximation of the skin edges of a wound, very fine non-absorbable, non-irritating suture material is clearly superior to any type of absorbable material. For very delicate work, fine horsehair or an equally fine weight of one of the various synthetic dermal sutures is the ideal material. There will be less trauma if the needle is swedged on the suture instead of being threaded. For ordinary use in emergencies, however, the non-irritant qualities of fine silk so closely approximate those of horsehair and dermal suture that the greater cheapness and availability of silk make it the material of choice for skin sutures.

3. *Stay Sutures.* If stay or tension sutures are desired for helping to close the wound of an emergency operation, there is no reason for choosing material other than what one prefers for operations of election. The material chosen should be non-absorbable. In contrast to what has been stressed above, the size of the suture, whether it be silkworm gut, braided silk, synthetic suture material, steel wire or silver wire, should be *large*. Large size is advocated not because of increased tensile strength but because it tends less to cut through tissues by pressure necrosis. Whether stay sutures be placed through all or only the upper layers of a wound is best left to the discretion of the surgeon. They should never, however, be tied with too great tension of their own in an effort to relieve tension on other suture lines.

## DRAINS

In an article of this kind there is properly only one thing to emphasize about drains. If a drain must be used in an emergency laparotomy for any purpose other than to tap a duct or hollow organ, there is no question of the great margin of safety in the use of a soft rubber dam or gutta-percha tissue drain over any other type of rubber tubing or other material. Where small wounds must be drained, strips of thin gutta-percha, ordinary rubber bands, and even small twists of silk or chromicized catgut are useful substitutes for rubber dam. Whether rubber dam is used alone, or as a so-called "cigarette" drain of gauze folded within rubber dam, is a matter for the individual surgeon to decide. Drains should be sewn to the skin edge as soon as they are placed in a wound, not only to help prevent their coming out but more particularly to prevent their accidentally disappearing within a wound and becoming overlooked and forgotten.

## DRESSINGS

Under this heading should be considered both the gauze sponges used at emergency operations and the dressings for covering the wound at the conclusion of the operation.

*Accidental Wounds.* The use of sponges in the surgical care of accidental wounds other than abdominal presents few problems. Two or three things, at least, should be remembered. One is to standardize on one size of gauze sponge, preferably the 3-inch square, folded once. Another is that a gauze sponge wrung out in sterile physiologic saline solution causes less tissue trauma and avoids dealing with a "sticky" wound. Third, if air suction is easily available, a small glass suction tip such as is used in brain surgery is useful in conjunction with irrigation of the wound to save sponging. Fourthly, the careful use of a tourniquet during operations on the extremities greatly reduces the need for

sponging and to that extent saves tissue trauma.

*Emergency Laparotomies.* The choice and use of sponges for emergency laparotomies involves much more important problems. Safeguarding against loss of a sponge within the abdominal cavity is a paramount consideration. It follows from this that a single, or at most two standardized sizes and types of hand sponge are the easiest to count and to handle. Suggested for one of these is a folded gauze sponge  $8 \times 6$  inches, made from a single piece of gauze  $36 \times 24$  inches, and eight layers thick when folded. The other is a so-called Mikulicz pad 12 inches square, made of several layers of gauze sewed together and with a telltale of half-inch cotton tape, to which can be attached a clamp or ring. Each of these sponges is of a size not likely to be overlooked in an abdominal wound. It should be a rule, however, to

wait for the sponge count in emergency operations before starting to close the peritoneum, double checking with a formal search of the wound for any stray sponges at the time the count is being made.

Of the dressings to be used at the conclusion of operations little need be said save that they should neither be too tight nor too bulky. Splints should be available for use in operations on the extremities whether a fracture is involved or not.

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# STUDIES ON HEXYL-CHLORO-M-CRESOL AND OTHER CARBOCYCLIC ANTISEPTICS\*

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ALTHOUGH the terms antiseptic and disinfectant are generally understood and defined by all, Patterson<sup>1</sup> points out that historically both were coined and used before there was any exact knowledge of bacteria. Sir John Pringle introduced the term antiseptic in 1750 and applied it to substances preventing putrefaction. The Federal Food and Drug Act of 1928 stated that salves, ointments and dressings which remain in contact with the body for long periods were to be considered antiseptics if they inhibited bacterial growth. On the other hand, mouthwashes, gargles, douches and preparations for similar uses (skin preparations) which were in contact for but a brief period of time were to be considered antiseptics only if they killed bacteria in the dilutions recommended and in a comparatively short time. The statement of the Food and Drug Act would make the words disinfectant and antiseptic synonymous in most of the present day applications. Perhaps it is for this reason that most of the substances used by both the public and the medical profession for antiseptic or disinfectant purposes are spoken of as germicides or as possessing certain germicidal activity.

Relatively little is proved regarding the mechanism of disinfection. Pringle, in 1750, first advanced the theory that it was associated with coagulation of protein. Ward, almost 150 years later, gave the first objective evidence supporting Pringle. The modern statement of this theory may be quoted from the work of Wilder D. Bancroft and G. Holmes Richter:<sup>2</sup> "Disinfection in the light of colloid chemistry indicates that antisepsis is merely a state of narcosis, which depends upon the reversible coagulation of the cell colloids;

disinfection is brought about by the irreversible coagulation of the cell colloids." Objection is brought to the coagulation theory that there should be a parallelism between the coagulation of plant and animal proteins and that many of our more active inhibiting or destructive agents do not coagulate animal proteins. In fact, one of our ideals is to find an agent which has a selective bactericidal property but does not destroy the tissue cells.

Whatever theory we adopt or is finally proved correct, we have at present a good knowledge of many of the factors controlling the actual process of disinfection and antisepsis. They may be listed as follows:

A. Concentration of organisms and time. A bacterial suspension exposed to a disinfectant shows a gradual decrease in the number of living cells, the number dying during any period being a certain fraction of the number living at the beginning of the exposure.

B. Concentration of disinfectant. The greater the amount of chemical originally added the more rapid the destruction.

C. Medium in which the disinfectant acts. The presence of organic material in the suspension usually decreases the activity of the disinfectant and acidity increases it.

D. The type of organism. Activity of a substance against one organism or one group of organisms gives no clue to the activity against another group. The F. D. A. method includes the use of *S. aureus* and *E. typhi* and most simple substances showing satisfactory killing power against one are weak against the other. This explains the necessity of using complex chemical compounds or mixtures of two different chemical groups.

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E. The criterion on which death is based. Organisms may grow on artificial media after exposure to a disinfectant but fail to infect animals. The organism is more apt to show survival on enriched media and at 37°C. Death or survival therefore may depend on the test employed.

The present study was stimulated by a desire to find a substance of high bactericidal activity and low tissue toxicity to be used in conjunction with tannic acid in the treatment of burns. The studies of Salle and Lazarus<sup>3</sup> on the "toxicity index" of antiseptics indicated that most of the substances now in use were too destructive to tissue cells to be used on large burned surfaces where uninjured cells must be preserved and given proper conditions for growth.

Obviously, general systemic toxicity was to be avoided even more than local tissue toxicity; hence the salts of heavy metals and phenol were considered unsuitable despite their use by some manufacturers in very low concentrations of questionable bacteriostatic value.

Having used various tricresol derivatives in the preparation of bacterial vaccines and being impressed with their sterilizing action and their low toxicity on subcutaneous injection, we thought the use of this group as an antiseptic combination with tannic acid logical. Utilizing the F. D. A. method of testing, amyl-tricresol in solutions made up with water 25 per cent, alcohol 25 per cent, and glycerine 50 per cent, was found effective against *S. aureus* in ten minutes in 1:4000 dilution and against *E. typhi* in 1:2000. However, a similar solution containing 5 per cent tannic acid became effective in dilutions of 1:28,000 against *E. typhi* and 1:24,000 against *S. aureus*. As pointed out in a preliminary note<sup>4</sup> this increased activity was due for the most part to the lowering of the pH, although some acids, such as hydrochloric, increase the activity proportionately more than other acids tried.

The tannic acid-tricresol preparations were tried on burned surfaces, but produced

some irritation when first applied and were abandoned although the wounds remained free of infection and healing was satisfactory. The partial success with these cresols led to trial of many related compounds,<sup>4</sup> but the cresol base with the incorporation of a hexyl radical and one or more chlorine radicals remains the most effective antiseptic.

In 1921, Johnson and Lane<sup>5</sup> systematically investigated the influence of the introduction of alkyl groups on the antiseptic properties of resorcinol. They found that the antiseptic value of resorcinol is markedly increased by the introduction of an alkyl group into the nucleus and further that the increase is related to the size of the group introduced. For example, if the phenol coefficient of resorcinol is placed arbitrarily at 1.0, the introduction of an ethyl group raises the coefficient to 4.9, the introduction of an n-propyl group raises the coefficient to 13.8 and the introduction of an n-butyl group raises the coefficient to 25.6.

Following the lead of Johnson and Lane, Dohme, Cox and Miller<sup>6</sup> extended the alkyl series of resorcinol to the dodecyl derivatives and their tests showed a steady rise in the phenol coefficients with the size of the alkyl group introduced, reaching a peak with the hexyl derivatives.

In the synthesis of all these alkyl resorcinols the method used was that of Nencki and Sieber<sup>7</sup> which consists in the condensation of corresponding fatty acids with resorcinol in the presence of zinc chloride. The ketones thus obtained are reduced with zinc amalgam and hydrochloric acid according to Clemmensen's<sup>8</sup> method.

Another method of increasing the antiseptic activity of carbocyclic compounds, second only to the introduction of alkyl groups, is the introduction of halogens. This method, though known for some time, has been utilized chiefly by Klarmann and his associates<sup>9</sup> in the production of several chlorophenols.

Working along the lines mentioned above, many carbocyclic derivatives have been synthesized, including seven appar-

distilled in high vacuum, is a clear oil. The Rosenmund and Schnurr<sup>11</sup> rearrangement reaction with  $\text{AlCl}_3$  was applied to the

### Preparation of Hexyl-dichloro-Resorcinol.

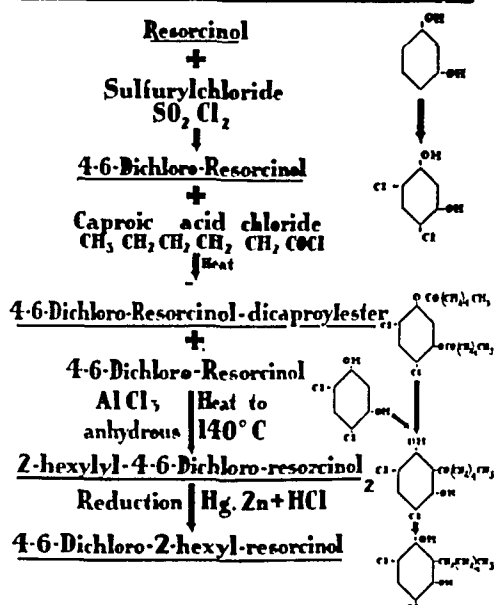


FIG. 1.

ently new hydroxy-chloro-alkyl-benzenes, namely 4-chloro-6-hexyl-resorcinol, 4-6-dichloro-2-hexyl-resorcinol, 6-chloro-4-hexyl-m-cresol, 4-6-dichloro-2-hexyl-m-cresol, iodo-mercuri-hexyl-chloro-m-cresol, bromo-hexyl-chloro-m-cresol, and 2-4-dichloro-6-hexyl phenol. All seven of these derivatives are highly effective antiseptics but we wish to emphasize but two (dichloro-hexyl resorcinol and hexyl chloro-m-cresol) in this paper since only these have received an extensive clinical trial as well as exhaustive laboratory tests.

### METHODS OF PREPARATION

**4-6-Dichloro-2-Hexyl Resorcinol.** Resorcinol is chlorinated in ether solution with sulphuryl chloride according to the method described by Moore, Day and Suter.<sup>10</sup> The resulting dichloro-resorcinol is distilled under reduced pressure. It is a white crystalline substance, melting point 112–113°C. The dicaproyl ester of this compound was formed by the action of 2 molecules of caproylchloride for 1 molecule of dichloro-resorcinol. This compound, when

### Preparation of 4-hexyl-6-Chloro-m-cresol.

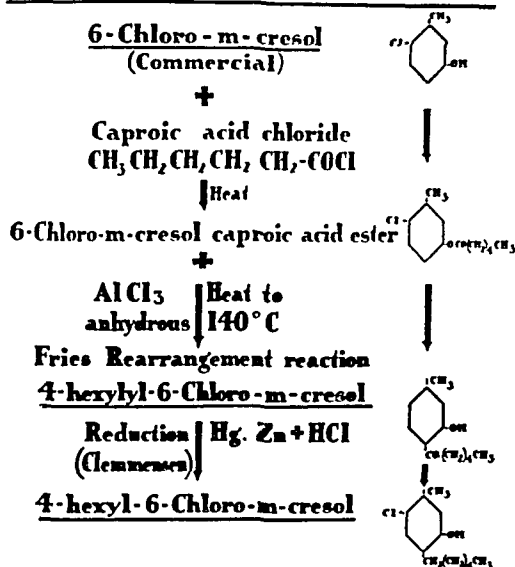


FIG. 2.

diester. Advantage was taken of the observation of Stoughton, Baltzly and Bass<sup>1</sup> that the second alkyl group of the diester in the rearrangement of di-hydroxi-benzenes can be included in the reaction by adding 1 molecule of the free phenol. The proportion of the reacting substances in this case was accordingly as follows: 1 molecule of dichloro-resorcinol-dicaproyl ester, 1 molecule dichloro-resorcinol and 2.2 molecules anhydrous  $\text{AlCl}_3$ . The resulting ketone hexyl-4,6-dichloro-resorcinol is distilled in high vacuum. It is a yellowish oil which easily crystallizes in the cold (melting point 102°C.). The ketone is reduced with amalgamated zinc and HCl (Clemmensen) to the corresponding alkyl compound. 4-6-dichloro-2-hexyl-resorcinol distills in high vacuum at 174–177°C. It is a colorless liquid which on cooling crystallizes to a white mass (melting point 52°C.).

**6-Chloro-4-Hexyl-M-Cresol.** The starting material for this compound is the commercial chloro-m-cresol (2-chloro-5-hydroxytoluene Eastman). By the interaction of 1 molecule of this compound with 1 molecule caproylchloride the caproyl ester

is obtained. It is a clear liquid (boiling point 184–187°C. at 20 mm.). One molecule of the ester is heated with 1.2 molecule  $AlCl_3$  for one hour at 140–160°C. After the decomposition of the melt with concentrated HCl, the ketone is obtained as a solid mass. It is reduced according to Clemmensen with amalgamated zinc and HCl to the corresponding alkyl compound. This is a colorless oil when distilled under high vacuum (boiling point 148–150°C.) and crystallizes to a white mass in the cold.

One difficulty with the carbocyclic group as a whole is the low solubility in water. None of them show a solubility in water of more than 1:2000. Solvents containing glycerine, neutral soap, alcohol and propylene glycol have given the best solutions. Frequently a satisfactory clear solution is again turned into a suspension when further dilution with water is attempted. Three solutions have been used in testing, glycerine 35 per cent, alcohol 25 per cent, and water 40 per cent; glycerine 20 per cent, duponol .33 per cent, water 80 per cent; and propylene glycol 35 per cent, alcohol 25 per cent, and water 40 per cent. For wound antisepsis or mucous membranes a solvent of propylene glycol 40 per cent, duponol .1 per cent and water 60 per cent is recommended. For skin preparation a solvent of alcohol 50 per cent, acetone 10 per cent, and water 40 per cent. Suspensions of various substances in glucose 20 per cent, duponol .1 per cent, alcohol 1 per cent have been used experimentally in animals.

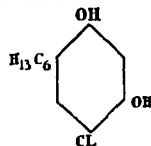
#### LABORATORY TESTS

In accordance with present accepted standards the method of testing antiseptics for activity against bacteria recommended by the U. S. Food and Drug Administration,<sup>13</sup> including the Shippen modification, was employed throughout. The strains of *S. aureus* and *E. typhi* were those furnished by the F. D. A.

Comparison of the resistance of bacteria and embryonic tissue to antiseptics (the toxicity indices) was carried out by the

original method of Salle and Lazarus.<sup>3</sup> Nye<sup>14</sup> has criticized this method and it has now been modified.<sup>15</sup> Whether fundamentally

#### 6 Hexyl-4-chloro Resorcinol



1-2000 Sol Glycerine		20% Duponol .33% in H <sub>2</sub> O	
F.D.A. Method - Shippen mod.		Salle & Lazarus Method	
Highest dil kills in 10 min. not in 5		Tissue culture	Toxicity index
A	B	C	C/A C/B
<i>S. aureus</i>	<i>E. typhi</i>		
22000	1000	7000	.31 7.0
plus .36% HCl			
30000	15000		
1-2000 Sol Glycerine 50% Alcohol 25% H <sub>2</sub> O 25%			
28000	2000		
plus 5% lactic acid			
36000	24000		
plus .36% HCl			
68000	48000		

FIG. 3.

valid or not, the results obtained are relatively accurate and are presented merely for comparative evaluation.

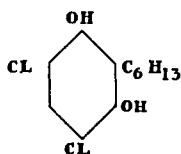
**Hexyl-Chloro-Resorcinol.** This is a colorless heavy liquid or a white amorphous substance sparingly soluble in water but readily soluble in alcohol and propylene glycol. As indicated in the chart, solutions are made either with glycerine and a neutral soap (duponol) or with glycerine and water. Solutions for use as a skin antiseptic are made up with alcohol 50 per cent, acetone 10 per cent, and water 40 per cent. Using the Shippen modification of the F. D. A., this material killed *S. aureus* in dilutions of 1:22,000 and *E. typhi* in dilutions of 1:1000 in ten minutes. Cultures of chick heart were inhibited in dilutions of 1:7000, giving a toxicity index of .31 with *S. aureus* and 7.0 with *E. typhi*. The addition of 0.36 per cent HCl to this solution resulted in increasing the killing dilutions of 1:33,000 with *S. aureus* and 1:15,000 with *E. typhi* in ten minutes.

Solutions made with glycerine, alcohol, water, including .36 per cent HCl, are still more active, being effective in ten minutes against *S. aureus* in dilutions of 1:68,000 and against *E. typhi* in dilutions of 1:48,000.

This difference in the two solutions is due to the neutralizing effect of the neutral soap in the first instance. This product has been

but is readily soluble in alcohol and propylene glycol. For antiseptic purposes a watery solution is made with glycerine

### Di chloro - Hexyl Resorcinol



1-1000 Sol. Propylene Glycol 35% alcohol 25% H<sub>2</sub>O 40%  
FDA Method - Shippen Mod. Salle & Lazarus Method

Highest dilution kills in 10 but not in 5 min.		Tissue culture	Toxicity index	
A	B	C	C/A	C/B
<i>S. aureus</i>	<i>E. typhi</i>	3500	.08	2.3
40000	1500			
plus .36 Hcl				
90000	44000	7000	.07	.14

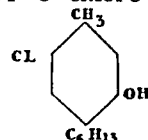
FIG. 4.

used clinically where watery solutions were desirable because of its solubility, especially in solutions and jellies used in combination with tannic acid for the treatment of burns. The tissue toxicity is low, as indicated by tissue culture method, animal inoculation and clinical observation.

**4-6-Dichloro-2-Hexyl-Resorcinol.** This material is similar in physical characteristics to hexyl-chloro-resorcinol except that it is somewhat less soluble in water. In the propylene glycol alcohol solution indicated in the chart it is effective in ten minutes against *S. aureus* in dilutions of 1:40,000 and against *E. typhi* in dilutions of 1:1500. Cultures of chick heart are inhibited in dilutions of 1:3500. The resulting toxicity indices are .08 with *S. aureus* and 2.3 with *E. typhi*. Adding .36 per cent HCl to the solution it is effective in ten minutes against *S. aureus* in dilutions of 1:90,000 and against *E. typhi* in dilutions of 1:44,000. Chick heart cultures are inhibited in dilutions of 1:7000, thus toxicity indices are .07 with *S. aureus* and .14 with *E. typhi*.

**4-Hexyl-6-Chloro-M-Cresol.** This material is a heavy, colorless solution when warm, but grayish-white crystals when cold. It is only moderately soluble in water

### 4 Hexyl - 6 - chloro - m - cresol



1-2000 Sol. Glycerine 20% Duponol 33% H <sub>2</sub> O 80%		FDA Method - Shippen Mod.	Salle & Lazarus Method
Highest dil. kills in 10 min. but not in 5 min.		Tissue culture	Toxicity index
A	B	C	C/A C/B
<i>S. aureus</i>	<i>E. typhi</i>		
70000	400	1300	.019 3.
plus .36% Hcl			
190000	4000	4000	.02 1.
1-2000 Sol. Glycerine 20% alcohol 25% H <sub>2</sub> O 55%			
plus tannic acid 5%			
124000	4000		
plus .36% Hcl			
200000	36000		

FIG. 5.

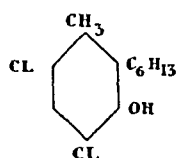
20 per cent, duponol .33 per cent, alcohol 10 per cent and water 69.67 per cent. An alcoholic solution for skin preparation is made up with alcohol 50 per cent, acetone 10 per cent and water 40 per cent.

In watery solution this material kills *S. aureus* in ten minutes in dilutions of 1:70,000 and *E. typhi* in dilutions of 1:400. Chick heart cultures are inhibited by dilutions of 1:1300. The toxicity indices produced are .019 with *S. aureus* and 3 with *E. typhi*. The addition of .36 per cent HCl to this watery solution increases the effectiveness to dilutions of 1:190,000 with *S. aureus* and 1:4000 with *E. typhi*. The toxicity indices are also changed to .02 with *S. aureus* and 1 with *E. typhi*.

In alcoholic solutions or glycerine and alcohol solutions this substance is more active, especially when made up with .36 per cent HCl, killing *S. aureus* in ten minutes in dilutions of 1:200,000 and *E. typhi* in dilutions of 1:36,000. The indicated effectiveness against the F. D. A. strain of *S. aureus* is, as far as can be ascertained, the highest reported for any chemical with such relatively low tissue toxicity. The killing power in ten minutes of the alcohol acetone solution containing .36 per cent HCl for other organisms

commonly found on the skin was determined as follows: *Es. coli* in dilutions 1:38,000; *B. pyocyaneus* in dilutions of

#### 4-6 Dichloro-2-Hexyl-m-cresol



1-1000 Sol. Propylene Glycol 35% alcohol 25% H <sub>2</sub> O 40%		Salle & Lazarus Method	
FDA Method—Shippin Mod.		Tissue culture	Toxicity index
Highest dil. kills in 10 min but not in 5 min			
A	B	C	C/A C/B
<i>S. aureus</i> 130000	<i>E. typhi</i> 1000	8000	.06 8.
plus .36 Hcl 200000	5000	10000	.045 2.

FIG. 6.

1:27,000; *Streptococcus viridans* in dilutions of 1:240,000; *Streptococcus hemolyticus* in dilutions of 1:440,000, and *B. welchii* in dilutions of 1:26,000.

Hexyl-chloro-m-cresol is the antiseptic which has been in general use throughout the hospital for three years, having been employed in more than 5000 major and 10,000 minor operations, and 1200 obstetrical preparations. In the clean surgical cases the percentage of infection during the last twelve months has been 0.1 per cent, and the infections were all in scalp wounds. In the obstetrical work no infections in skin wounds have been seen and the postpartum course of the patients has generally been more satisfactory than with the type of preparation previously employed. As a rule a watery solution 1:2000, glycerine 20 per cent, duponol. 33 per cent and water 79.67 per cent is used in wounds and on mucous membranes, while the alcoholic solution 1:1000, alcohol 50 per cent, acetone 10 per cent and water 40 per cent is used in all skin preparations.

**4-6-Dichloro-2-Hexyl-M-Cresol.** This product has physical properties similar to hexyl-chloro-m-cresol and despite the additional chlorine radicals is less active than the mono-chloro-hexyl-m-cresol. It is also less soluble. Numerous comparable at-

tempts to introduce other halogen radicals has failed thus far to improve the derivatives.

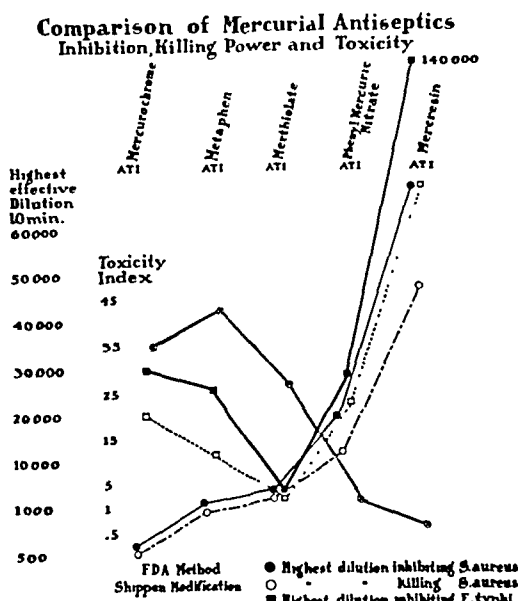


FIG. 7.

#### DISCUSSION

Of the various carbocyclic antiseptics synthesized and tested to date, dichloro-hexyl-resorcinol and hexyl-chloro-m-cresol are superior. The former has been used particularly in the tannic acid preparation for burns and the latter has been used as a general hospital antiseptic. The clean surgical cases in the general surgical service of Dr. Roy D. McClure, prepared with hexyl-chloro-m-cresol, have not shown a single wound infection in the last twelve months. This excellent clinical record, coupled with the high bactericidal activity and low tissue toxicity of the material, demonstrated in repeated laboratory observations, indicate its acceptability as a general antiseptic.

When comparative evaluation of hexyl-chloro-m-cresol is undertaken, the antiseptics in common use must be listed and tested in the same manner. Probably the six antiseptics in most general use are iodine, mercurochrome, metaphen, merthiolate, phenyl mercuric nitrate, and mercresin. The five mercury compounds

are listed in Figure 7. They are arranged in order of their effectiveness against *S. aureus* and tissue toxicity from left to right. Mercurochrome has the highest toxicity index and is the least effective against *S. aureus*, but is somewhat more active against *E. typhi*, especially as an inhibitor. In view of the high activity of hexyl-chloro-m-cresol it is interesting to note that the most active mercurial (mercresin) against both *S. aureus* and *E. typhi* is not a chemical compound but a mixture of ortho-hydroxy-phenyl mercury bichloride and five isomeric amyl-ortho-cresols.

Brewer<sup>16</sup> reached the following conclusions among others in a recent study of the mercurials used as antiseptics, including all five of those mentioned above: "To explain the ability of some of the mercurials to act as antiseptics is beyond the scope of this paper. However, their actual germicidal value for vegetative bacteria is questioned. After it was found that the mercurial solutions as commonly used are incapable of killing the spores of the pathogenic anaerobes in twenty-four hours, it was decided to determine their effect on some vegetative bacteria by the centrifuge method. Just as statements are made that some of these mercurials will kill spore-forming bacteria, some of the manufacturers claim that their particular product will kill vegetative bacteria in ten minutes. One of the mercurials used did not kill *Staphylococcus aureus* in thirty minutes, although no neutralizers or special recovery methods were used. Other vegetative bacteria were used and the results indicate that some method other than one based on phenol coefficient determination should be used to establish the ability of the mercurials to disinfect instruments."

As for iodine, the tincture was effective in ten minutes F. D. A. method against *S. aureus* in dilutions of 1:9000 and against *E. typhi* in dilutions of 1:11,000. The toxicity index was 0.1. The principal criticism of iodine is the fact that skin burns not infrequently result if it is left on the skin during the operation or is applied

full strength to the axillae, inguinal regions or about the genitalia.

Compared with hexyl-chloro-m-cresol, the mercurials are less effective against *S. aureus* and are much more toxic for tissue cultures. Against *E. typhi* mercresin, containing uncombined amyl-ortho-cresols, is more effective. In comparison, iodine is much less effective against *S. aureus*, somewhat less effective against *E. typhi*, and has a higher toxicity index than the hexyl-chloro-m-cresol in solutions brought to pH of 3.

### CONCLUSIONS

1. A new antiseptic, hexyl-chloro-m-cresol, is described along with other compounds of the carbocyclic group.
2. These compounds are heavy, colorless liquids or white solids, are practically odorless and are sparingly soluble in water.
3. Dichloro-hexyl-resorcinol and hexyl-chloro-m-cresol are unusually effective bactericidal substances, especially against staphylococci, streptococci, pyocyanus, and the Gram-negative bacilli when their solutions are acidified to pH of three with HCl or other acids.
4. Toxicity, both locally and systemically is comparatively low, hence danger from absorption or ingestion of the 1:1000 solutions is negligible.
5. A highly satisfactory performance in an extended clinical trial coupled with laboratory tests showing low toxicity for tissue cells and unusual effectiveness against bacteria indicates that these substances are most acceptable general antiseptics.

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# TREATMENT OF BURNS\*

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THROUGHOUT the years few injuries have approximated the sum total of human misery associated with the severe burn. Modern civilization, while increasing the load of pain and death, until recent years has offered little encouragement in the attempt to lessen the suffering resulting from this form of bodily injury. Statistics prove the statement that severe burns constitute one of the most serious hazards of modern times, as regards human existence and well being.

The surgeon confronted by the prospect of treating a seriously burned patient accepts a great responsibility. He must expect to spend countless hours of close attention and supervision, with periods of mixed anxiety and discouragement before the case is terminated, and always present is the grim realization that in spite of all efforts, a fatal outcome may supervene.

It has been said that during the first twenty-five years of the present century, severe burn cases approached the picture of the pre-Listerian or "laudable pus" days.<sup>1</sup> It is an unpleasant memory for many of us to recall the scenes associated with these extensive open wounds, bathed in purulent exudate requiring painful dressings, and all too inadequately treated with salves, ointments, and countless favorite medicaments. All of these, we now realize, added to the patient's suffering and the long period of convalescence.

Medical history has recorded a new era in the management of the severe burn case which may be said to have begun with the introduction of the tannic acid treatment. As stated by Wells,<sup>2</sup> "the introduction of tannic acid by Davidson in 1925 has revolutionized and, apparently for the

first time in history, standardized the treatment of diffuse burns." This contribution<sup>3</sup> to medical science has without doubt helped to lower the mortality in this type of case.

It has been through the experiences of workers in this field that the present form of treatment has been developed, as represented by the bibliography and references listed by Harkins<sup>4</sup> in his recent review on the advances in the study of burns. A few of the older principles of treatment have been emphasized, but as our knowledge of physiology and pathology in relation to changes occurring in the human body increased, recent advances have been made which developed a more rational basis for therapy. The interchange of ideas and experiences, together with the emphasis of certain important points, has been most valuable. In accord with this view, a résumé of our present form of management of the severe burn is presented, together with a report of the results obtained. From time to time the method of treatment has been modified as the result of our experience, and in accordance with the suggestions of others. For the most part, we still adhere to the basic principles as proposed by Davidson, while working at the Children's Hospital of Michigan from 1927 until his death in 1933.

## GENERAL CONSIDERATIONS

Burns in children account for approximately 45 per cent of the deaths in the United States occurring annually from this type of injury,<sup>5</sup> and thousands of survivors are left with disfiguring and disabling scars. It has often been pointed

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out that the severity of burns in young children is increased by the delicate character of the epithelium. This is reflected in the mortality among young individuals and by the extensive scarring often encountered after healing. It has been noted that the mortality of burns of the face is relatively high. In two of six fatal cases occurring during the year 1938, the burned area was limited almost entirely to the face. There is apparently no adequate explanation for the severe reaction from such injuries. It is also a fact that burns involving the body or trunk are more serious than those of a corresponding size located on the extremities.

The large number of thermal injuries resulting from hot liquids has been mentioned by Davidson<sup>6</sup> in a review of the cases at the Children's Hospital. There has been no material change in this regard (Table 1) in cases treated in recent years,

TABLE 1  
ETIOLOGY OF BURNS  
1922-1938

	No.	Per Cent
Hot fluids (spilling hot liquids from table or stove, stepping or falling in hot water)	472	54.1
Fire (bonfire, stove, gas heater, gasoline, etc.)	218	25.0
Fire (results of playing with matches)	64	7.3
Chemicals	37	4.2
Not stated	82	9.4
Total	873	
Considered avoidable	711	81.4
Considered unavoidable	80	9.2
Not stated	82	9.4
Total	873	

and the age incidence (Fig. 1) remains practically unchanged.

Experience leads us to believe that the success attending the care of a severe burn case is in part dependent on the time interval elapsing between the injury and the institution of surgical treatment. Of equal importance is the condition of the burned surface when the patient is admitted.

It is apparent that the efforts of those interested in the treatment of burns have had some effect in bringing about the

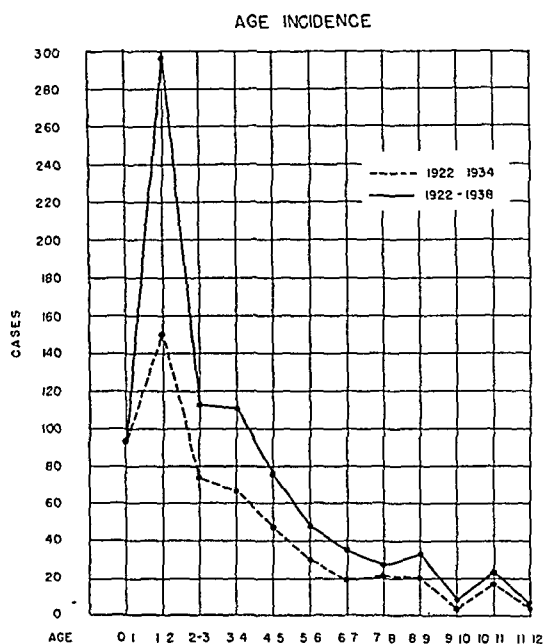


FIG. 1.

earlier hospitalization of many of these patients. Approximately 60 per cent of the burn patients admitted to the Children's Hospital of Michigan in the years 1934 to 1938 entered within 24 hours of the time of injury, as compared with 40 per cent admissions on the first day in the years 1930 to 1934. In many cases the importance of instituting prompt hospital treatment was recognized by the parents or attendants. The physician first called to see the patient also recommended immediate hospitalization, the only treatment given being the application of a sterile dry dressing and a sedative. The resultant saving of valuable time is reflected, we believe, in the more favorable mortality figures. Much is still to be desired in the education of the laity regarding prevention and the early hospitalization of the severely burned patient.

Investigators have determined that there are changes in the character of the blood in patients suffering from severe burns. Following a diffuse burn, there is hemoconcentration,<sup>7,8,9,10,11</sup> loss of blood plasma and



chlorides. This usually takes place within twenty-four to forty-eight hours following the accident. Davidson<sup>12,13</sup> found a hypoproteinemia. Harkins<sup>14,15</sup> states that the cells normally contain less chloride than plasma and since in burns the cells are increased, this would explain the finding of low blood chlorides on the basis of the hematocrit changes alone, but would not account for the difference in the results on blood chlorides reported by Davidson<sup>12</sup> and McIver.<sup>16</sup> It has been shown in a detailed study<sup>17</sup> of a group of children suffering from severe burns that early treatment will in many cases prevent these changes, or quickly reestablish the normal condition of the blood. Again the value of early treatment is indicated.

Certain metabolic changes complicate the more severe burns, as evidenced by early shock, delayed shock, sepsis and exhaustion. In addition, certain pathologic processes may develop, the more serious being pneumonia, nephritis, and gastroenteritis. The use of sulfapyridine in the treatment of pneumonia<sup>18</sup> and certain types of sepsis complicating serious burns has proved of benefit. Six cases have been treated to date by this form of therapy, with no deaths. No symptoms or clinical manifestations have developed in the course of treatment that contraindicate the use of this drug. In three of the six cases, the area involved approximated 40 to 45 per cent of the body surface. One child, seventeen months of age, had bronchopneumonia, and two showed clinical evidence of septicemia. This limited experience leads us to believe that the drug should prove of value in dealing with these types of complications. We do not advocate dependence on this form of therapy alone. The results, although encouraging, are not conclusive. With the use of sulfapyridine, there has been a decided lowering of the temperature (Figs. 2 and 3) in some cases by crisis. There was also improvement in the clinical picture, especially noticeable in chest lesions. The drug has not been prescribed as a prophylactic measure, but in

selected cases it should prove a valuable adjunct in the treatment.

#### SHOCK AND TOXEMIA

The emergency treatment rendered the patient with a burn of minor extent deals mainly with the care of the local lesion. Shock as a complication is not important with this type of burn.

The diffuse burn requires hospitalization for adequate and safe treatment. It is important because of the early complications, the most serious of which is shock. Many lives are doubtless sacrificed as a result of the omission of this principle. From our own experience, and that of others, the incidence of infection is greatly minimized by proper early surgical care of the burn. The early surgical care, followed by the use of tannic acid<sup>3</sup> or gentian violet,<sup>19</sup> also minimizes the tendency to subsequent shock. Pain is reduced after the initial application of these agents, thereby diminishing the incidence of this complication. The extent of the burn bears some relationship to shock, but is not to be relied upon, as we have seen it occur in comparatively slight burns.

The initial shock associated with burns may be entirely due to pain, and also to the extent of the burn. This complication may be of a transitory character and not demonstrable when the patient is first seen by the physician, especially if there has been a lapse of time between the accident and his arrival. This primary type of shock is of neurogenic origin and is manifested by a fall in the blood pressure, a subnormal temperature, increased pulse rate, reduced pulse pressure, and occasionally by cold and clammy extremities.

The patient on admission to the hospital should be given sedation to relieve pain, codeine for children and morphine for adults. The patient should then be transferred in a sterile sheet to a warm first aid or operating room, where dry heat can be applied. The latter is best supplied by an electric blanket. When recovery from the initial shock is apparent, the burn

wound is debrided and given the necessary surgical treatment. This is supplemented by general measures such as intravenous saline and glucose solutions, and early blood transfusions. Saline and glucose temporarily raise the blood pressure and may be given to fortify the patient until blood is available. The temporary action of these agents is due to the rapid elimination by the kidneys; blood, on the other hand, prevents this because of its protein content. Of the blood, the serum alone is vital to this action.<sup>20</sup> In the blood bank there is available blood serum for immediate use in the severe burn case.

Underhill, Kapsinow and Fisk<sup>21</sup> maintain that following a burn, the permeability of the capillaries is in one direction only, namely, from the capillaries to the tissues. If saline or glucose only are available, the additional giving of adrenal cortex hormone may have some merit as the latter is supposed to restore and maintain capillary tone. The clinical experiences of Wilson, Rowley and Gray,<sup>22</sup> 1936, although limited, should be given careful consideration as regards the use of an extract of suprarenal cortex.

Blood concentration is a common accompaniment of a severe burn followed by an anemia, which is due to the loss of fluid at the site of the burn, poor nutrition and internal destruction of the blood. The cause of shock associated with the diffuse burn is still questionable, as is emphasized when one notes the conflicting opinions set forth.<sup>4</sup> Likewise, the cause of the toxemia associated with the diffuse burn may be questioned. Whether this is due to the absorption of chemical toxins from the site of the burn, or due to bacterial toxins, has not been proved. Further research may solve this problem.

#### LOCAL TREATMENT

1. *Preparation of the Involved Skin Areas.* The importance of thorough cleansing, combined with débridement of the involved skin areas, cannot be too strongly emphasized. This includes the removal of all

foreign material and necrotic tissue, the opening of blebs and blisters, and the removal of the loose skin, together with gentle but complete cleansing of the involved surfaces with saline and boric acid solutions. The use of green soap and solvents, such as ether and alcohol, may be necessary. In most instances the proper preparation of the burned area may be successfully carried out with little pain by the use of sedatives, such as codeine in the case of young children and morphine in older individuals. The use of light anesthesia is justified if any vigorous measures are required to prepare the involved areas.

2. *Tannic Acid.* The use of the freshly prepared aqueous solution of tannic acid in 5 per cent strength as a coagulant of the protein on the surface of a burned area, has stood the test of time. The application by spraying has been successful and is still popular. The use of prepared jellies or pastes of 5 per cent or 10 per cent tannic acid strength has been satisfactory, especially in the treatment of burns of the face, and when the freshly prepared solution is not available.

3. *Tannic Acid and Silver Nitrate.* The technique proposed by Bettman<sup>23,24</sup> combines the use of 10 per cent silver nitrate and 5 per cent tannic acid solutions. The tannic acid is applied either as a spray or in jelly form, followed shortly by the application of the silver nitrate solution. The claims for this technique, as stated by Bettman, have been substantiated in most instances, and we believe that this adjunct to the original tannic acid treatment has proved of distinct value.

4. *Gentian Violet.* Gentian violet in 1 per cent aqueous solution as advocated by Aldrich<sup>19</sup> can be conveniently combined with tannic acid. It is our practice to use the dye in burns showing evidence of infection when first seen, or in cases of more than forty-eight hours' duration when first treated. Burns involving the perineum, the hands and feet, and deep burns encircling the extremities or in the region of joints should be treated with gentian violet

solution. The dye may also be combined in the treatment, following the use of tannic acid, where there is separation and evidence of infection about the edges of the coagulum.

5. *Gentian Violet and Silver Nitrate.* Following the experience with silver nitrate combined with tannic acid, a similar technique was used substituting gentian violet for tannic acid. The results in a small series of cases were satisfactory and provided the basis for a published report.<sup>25</sup> This combination has to some extent offset certain disadvantages of the gentian violet solution when used alone. A firmer coagulum is produced, drying is more rapid, and the disagreeable staining properties are somewhat limited. In addition, the antiseptic properties of the gentian violet solution appear to be increased by the combination with silver nitrate.

The burn resulting from acid or an alkali should always be thoroughly washed with water before applying the neutralizing agent. Sodium bicarbonate solution is effective in the case of the acid burn, and acetic acid may be used as the neutralizing agent for the alkali burn.<sup>26</sup>

#### LATER TREATMENT

Following the local application of one or a combination of the various preparations mentioned, and the formation of a protective covering, the treatment of the lesion resolves for the most part into close observation and the early detection of any unfavorable symptoms. It is convenient to treat the patient during this stage under the so-called "burn tent" and without dressings or covering of the involved areas other than provided by the coagulum. The temperature within the tent should be maintained at 85 to 90°F. Since these patients have a lowered resistance to infection, respiratory complications may follow extreme changes in temperature.

The problem of local infection is always to be borne in mind, and if it does develop, the subsequent treatment must be based on the patient's reaction to this infection.

The removal of the coagulum may be necessary if the evidence of absorption increases to an alarming extent. The coagulum should be left intact, if possible, for a period of ten days or two weeks. Davidson<sup>3</sup> pointed out the dangers of disturbing the crust or applying softening agents in the first week of treatment, as he observed that a number of the patients had a recurrence of toxemia when the crusts were softened by wet compresses. If it is deemed necessary to remove the coagulum in cases of extreme infection, this can be performed under light general anesthesia.

The preparation of the denuded surface following the removal of the coagulum in deep burns may necessitate exposing the exuberant granulations to the air or to a heat lamp for purposes of retarding the growth by shrinkage and dehydration. Where extensive infection is present, the application of compresses saturated with half strength Dakin's solution may be used. Boric acid or normal saline solutions are applied if the infection is of lesser degree. The removal of exudate and small portions of coagulum can be further hastened by immersing the part in the brine bath. It should be noted that this latter procedure may be exhausting to the weakened patient. The brine bath treatment, in the early stages of the extensive burn case, as advocated by Blair and Brown,<sup>27</sup> has not been used.

Early skin grafting is desirable in all cases requiring the transfer of epithelium to the denuded surfaces. In many cases this is a life saving measure, and often through early grafting extensive scarring and deformities can be prevented. To allow a large granulating surface resulting from a burn to remain as a definite hazard to the recovery of the patient is gross negligence on the part of the surgical attendant. In our experience the deep pinch graft has proved successful in a large number of cases where there was extensive involvement of body surfaces. The advantages are (1) the success obtained with this

type of grafting in the presence of considerable infection, (2) the covering of areas of considerable extent, which is

The importance of close attention by the surgeon during the treatment of the healing stage must again be emphasized. The prev-

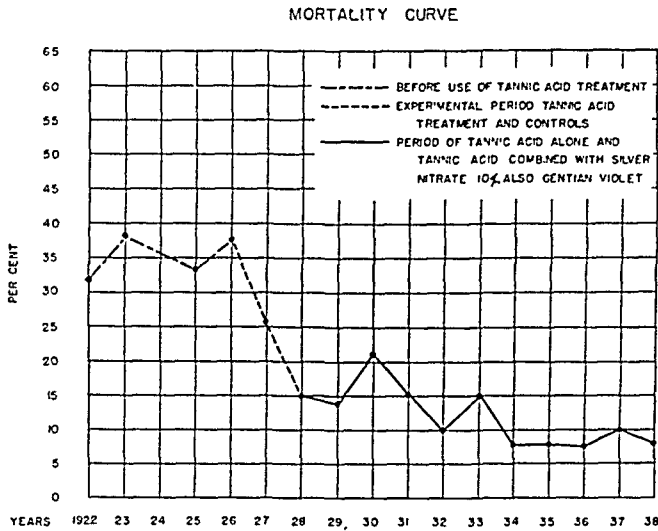


FIG. 4.

possible with little shock to the patient when carried out in short operative stages. The proponents of the Thiersch and split thickness grafts have much in their favor, and undoubtedly this type of grafting has been very satisfactory in trained hands. The treatment of contractures and disfiguring scars is a problem for leisurely consideration and does not fall in the scope of this discussion.

Many preparations have been cited as possessing the property of stimulating regeneration of epithelium in the case of extensive burns. Our experience with a number of such preparations leads us to believe that for the most part such forms of therapy are of minor importance in the treatment of the more severe types of burns. However, scarlet red gauze, prepared according to the formula given by Bettman,<sup>23</sup> definitely aids in the healing of small granulating surfaces, and provides a satisfactory dressing in the healing stages following skin grafting of more extensive areas. During the stages of healing and the grafting of extensive granulating areas, small blood transfusions are of value in combating the state of exhaustion complicating these cases.

absence of disabling deformities as the result of negligence in the care of such lesions has been the subject of a previous article.<sup>28</sup> Attention to maintaining proper position during the healing stage can prevent, in a measure, these serious complications, and may mean the difference between a satisfactory outcome and a condition which cannot be sufficiently improved by corrective treatment. Teamwork is necessary to achieve a satisfactory result in the treatment of severe burns. The attending and house staffs, together with the nursing personnel, must cooperate in providing the proper care, while attention to all details of treatment must be closely adhered to.

#### RESULTS OF TREATMENT

The treatment as outlined is not claimed to approach the ultimate goal in caring for severe burns. Much remains to be accomplished in this respect, but adherence to the principles herein advocated will give satisfactory results in view of the present knowledge of the subject.

The advantages of the tannic acid treatment are as follows:

1. The coagulum produced by tannic acid minimizes toxemia resulting from absorption from the burned area.<sup>3,29</sup> Considerable doubt has been thrown on the theory of toxic absorption in relation to burns. Davidson believed that the theory did not satisfactorily explain all the symptoms in severe cases of diffuse burns, but there was convincing evidence that absorption of a toxic substance, formed at the site of a burn, produced certain constitutional reactions. The work of Bardeen<sup>30</sup> supports this idea. In spite of attempts to discredit this theory, many workers in the field still adhere to the principle of toxic absorption.<sup>1,31,32,33</sup>

2. It lessens the loss of body fluids from the burned area. Although it appears that the loss of body fluid from the burned area is not so great as previously thought, there is undoubtedly a considerable amount of "weeping," which is prevented by the forming of a coagulum.

3. The coagulum over the burned surface acts as a protection against infection. The tannic acid coagulum provides a physical barrier to the entrance of bacteria. Also, close adherence to the basic principles in the care of this type of surgical lesion prevents to a considerable degree the development of infection.

4. It lessens pain, thereby minimizing shock. Clinical observation has given conclusive evidence in support of this statement.

5. The treatment combined with the use of the light tent simplifies the care of burns. This claim needs no discussion.

6. The protective layer of coagulated protein forms a scaffold for the growth of the young epithelial cells over the denuded surface.

7. This method of treatment, supplemented by supportive measures, has materially reduced the mortality in cases of diffuse burns. The mortality statistics for a period of years preceding and following the introduction of the tannic acid treatment at the Children's Hospital of Michi-

gan are graphically shown. (Fig. 4.) The average mortality since the introduction of this form of treatment is 11.5 per cent. During the years 1932-1938 the mortality has averaged approximately 8 per cent. It is recognized that the statistics, for the years referred to, reflect improvement not only in the local treatment, but also in all supportive measures used to improve the general condition of patients suffering from severe diffuse burns.

#### SUMMARY

1. The severe burn case carries a responsibility not only for the attending surgeon, but for all individuals participating in the treatment. Close attention to details of therapy is essential.

2. The burn must be treated as a surgical wound preliminary to the application of the therapeutic agent.

3. Shock is an early complication and must be dealt with by the early administration of sedatives, heat to the body, and parenteral fluids, in addition to blood transfusions.

4. The local agent used may depend upon the type of burn and the experience of the attending surgeon.

5. Sulfapyridine has proved of value in a limited number of cases with sepsis and upper respiratory complications.

6. The acid or alkali burn should be thoroughly washed with water before applying the neutralizing agent.

7. Attention to the position of the patient is important to prevent contractures and deformities, and to obtain the best functional result.

8. It should be emphasized that attention to the nutrition of the patient is important and may be supplemented by frequent small blood transfusions to combat the secondary anemia, which is associated with exhaustion.

9. Early skin grafting minimizes loss of fluid from the burned area. The effects of infection are also reduced, thereby limiting scarring and contractures.



10. Physiotherapy may assist in the rehabilitation of the patient and restoration of function.

11. The results of treatment in the severe burn case show a favorable lowering of mortality by the use of modern therapy.

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# MODERN ASPECTS OF MANAGEMENT OF CRANIOCEREBRAL INJURY

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IN spite of nation-wide organized efforts to prevent accidents in our country, the number of injuries and deaths by this means still remains alarmingly high. Although accurate statistics are not yet available for the whole nation, it is estimated that at least 100,000 cases of cranio-cerebral injury are cared for each year. Although probably most of these are being cared for in the 2,030 hospitals which have been approved for surgery by the American College of Surgeons, undoubtedly many are being treated in smaller hospitals and some at home by general practitioners.

Statistical studies of large series of cases are of definite value and help in the general progress being made in management. But instead of attempting to report our experiences from a study of over 1200 cases of cranio-cerebral injuries treated in this hospital, we have planned to limit the scope of this paper to enumerating some practical points in management with special reference to some of its newer aspects. We hope that this may stimulate those who are not specialists to acquire for themselves from the literature a broader working knowledge, which should make for more satisfaction in the care of these cases and bring about better immediate and end results.

As evidence of an increasing general interest in this problem, over 700 articles were listed in the Cumulative Index of the American Medical Association for the last three years. An increasing number were experimental work dealing with the chemical and physiologic aspects.

We shall not concern ourselves here with the average case, labelled as concussion, in which little or no serious brain damage has occurred and where usually a good organic recovery results. But we are extremely

interested in the 20 per cent that have in the past been called contusions, lacerations and hemorrhage. And we would like to see a further reduction in the death rate which averages from 10 to 18 per cent. There are three types in this latter fatal group, which challenges us to improved methods of care: (1) those patients who are dying from localized removable clots or encysted fluid which are not being diagnosed and operated upon early enough; (2) those dying from anoxia because unfavorable cellular changes are permitted to develop from a recoverable to a hopeless state through misconceptions or ignorance of cellular physiology; and (3) those dying from the secondary effects of medullary and vasomotor shock which might be prevented if treated promptly and effectively.

A subject worthy of more emphasis than is possible here is a review of the anatomy and physiology of the brain and its circulation. One can better anticipate probable results of fractures of the skull if one remembers such points as: (1) the thinner more brittle inner table of the vault; (2) the closely adherent, rigid-walled, easily torn, blood sinuses at the base; (3) the half bony and half dural canal for the lower part of the middle meningeal artery just after it enters the skull through the foramen spinosum, as it is here that the artery is commonly torn across in skull fractures; (4) that venous stasis is an easily produced complication of brain swelling because of the roundabout, antigravity flow in veins and sinuses; (5) that destruction of brain cells is made easier because the arterial blood is carried by end vessels with little or no collateral circulation; and (6) that the normal circulation of the cerebrospinal fluid is easily interfered with because of

limited reserve space and the easily obstructed connecting aqueduct of Sylvius and foramina of Majendi and Luschka.

Physiopathologic facts also to be borne in mind are: (1) that aside from direct damage to, or cutting off of, the vital centers by tissue destruction, the most important disturbance that results from cerebral trauma is that affecting the circulation to and from the brain cells; (2) that shock, swelling of tissue, anemia, hyperthermia and depression by hypnotic and sedative drugs are apt to set up vicious cycles which may result in one or more forms of anoxia of sufficient severity frequently to produce characteristic destruction of brain tissue; (3) that brain cells are much more vulnerable to oxygen deprivation than other body cells and are destroyed if the oxygen is completely excluded for five to ten minutes; and (4) that apparently there is no regeneration of the important cells thus destroyed.

Fracture of the skull still seems to be held in the mind of the average layman, and particularly in a jury, as *the* important index of seriousness of head injuries. It has been brought out in many papers, apparently without enough general knowledge as yet, that the skull fracture of itself is important only in the following: (1) as an indication that the trauma has been at least fairly severe; (2) when the fracture is compound and thereby may have permitted foreign material to penetrate to the brain; (3) when the fracture has gone more or less horizontally across the lower part of the temporal bone and severed the middle meningeal artery as it lies in the canal which is part bone and part dura, thus resulting in the rapidly forming and potentially fatal extradural clot; (4) when the fracture has torn across a basal blood sinus, with its usual resulting fatal hemorrhage; (5) when the fracture extends across the petrous bone or the ethmoids, or into the frontal air cells, resulting in cerebrospinal rhinorrhea, with its risk of subsequent meningitis; and (6) if the fracture is depressed. Otherwise the type, location and

results of the brain damage are the important factors.

In earlier years the chief emphasis in management of brain trauma was the control of so called "compression." Surgical intervention was common. Death rates were high. During the last two or three decades more conservatism has been the rule and the non-surgical decompression of edema has been accomplished by lumbar punctures and dehydration. The amount of operating has been reduced. The mortality rates have been decidedly less than before.

But of late it has become apparent to many that still further improvements in results are possible. As they have in the past, so they will in the future depend upon the scientific advance in physiology and chemistry.

The destructive effect of cerebral trauma upon brain tissue and cerebral circulation has long been known and throughout the years considerable valuable experimental work has been done upon the various problems such as edema, anemia and hemorrhage. There has been accumulating more and more valuable information from experiments in the field of cellular physiology using biochemical and electrical methods. This is forcing a change in many of our old conceptions and is bringing about a gradual transition in some of the principles of management, with apparent benefit.

We shall not attempt to give a comprehensive list of the many contributions, but will mention a few which are pointing the way to further progress. After his excellent monograph with Rand<sup>1-6</sup> on cell changes from fatal cerebral trauma, Courville revived interest in the problem of cerebral anoxia.<sup>7,8</sup> Since then much work has been done by a number of investigators on the effects upon brain cells of oxygen deprivation, sedative and hypnotic drugs with results which compare with his findings.

Schreiber and Gates<sup>9</sup> and later Schreiber<sup>10</sup> reported studies made upon over 500 children, where apnea at the time of birth had been present in over 70 per cent of the infants. The study related the analgesics

given to the mothers at delivery, the apnea of the infants at birth, the later development of signs and symptoms of anoxia, and the subsequent objective evidences of cellular destruction.

Hartman<sup>11</sup> summarized the important data upon cerebral anoxia. The combined material in this and his previous reports, alone<sup>12</sup> and with Major<sup>13</sup> convincingly show that destructive cell changes, conforming to the pattern characteristic of anoxia, can occur from hyperthermia, narcotics and hypnotics, acute alcoholism, cerebral injury, and acute shock. Cell deprivation of oxygen seems to be common to all these conditions and it is reasonable to conclude that it is the important factor.

The effect of anemia upon brain cells was restudied by Gildea and Cobb<sup>14</sup> on cats. They corroborated the previous findings and concluded that ten minutes of complete cutting off of arterial blood is sufficient to produce permanent cellular destruction characteristic of anoxia. The earlier teachings had given the limit as five minutes.

The problem of anoxia is, of course, complex. Cellular deprivation of oxygen is intimately related to tissue and blood oxygen tension, sugar and other chemical constituents in the blood, and is definitely affected by sedative and hypnotic drugs and hyperthermia.

Gerard,<sup>15</sup> in an excellent summary of anoxia and neural metabolism, stated that the brain is thirty times as sensitive to oxygen deprivation as muscle or nerve tissue and that oxygen tension controls the utilization of sugar. Gellhorn, Ingraham, and Maldivsky<sup>16</sup> studied the influence of hypoglycemia on the sensitivity of the central nervous system to oxygen want. They found that the oxidative processes of the cells are diminished by the hypoglycemic state. Cheyne-Stokes respiration, present during experiments with low sugar content and reduced oxygen, could be abolished by increasing the blood sugar towards normal. McClure, Hartman, Schnedorf, and Schilling<sup>25</sup> found clinically and experimentally that the barbiturates, morphine

and avertin produced a sharp decrease in oxygen saturation of the blood and oxygen utilization by brain tissues. Unfortunately in trying to interpret pathologic findings no one can be certain which of the post-mortem cellular changes were present before and were a part of the cause of death, and which changes developed during the agonal stages which just precede death.

The mechanism of post-traumatic brain swelling and edema is a problem about which there is still no unanimity of opinion in spite of much experimental work. Because of the inherent difficulties, no one has yet been able definitely to prove the exact relationships of the various factors. Pilcher,<sup>17</sup> from a study of sixty experimentally traumatized dogs' brains, was unable to find conclusive evidence of edema and explained the increased pressure by disturbances of the blood and cerebrospinal circulations. Shapiro and Jackson<sup>18</sup> studied brains of fatal traumatic cases and by various methods of dehydration found that the subarachnoid fluid was not increased, but decreased, the brain swollen but not edematous. Part of the swelling was thought to be by ventricular distention and part by scattered hemorrhages. Both of these articles<sup>17,18</sup> contain excellent bibliographies.

As a result of the divergent views on this subject, therapy now varies between two extremes, on the one hand marked dehydration as advocated by Fay<sup>19</sup> and lumbar punctures advised by Munro<sup>20</sup>—and on the other, the extreme conservatism of Sachs<sup>21</sup> and Dandy.<sup>22</sup>

Other factors which cause an increase in cerebrospinal fluid pressure are blood, as shown by Bagley<sup>23</sup> and Parker and Lehman.<sup>24</sup> Schnedorf,<sup>25</sup> in experiments on dogs, found an increase in cerebrospinal fluid pressure and proteins, from simple cisternal withdrawal and immediate replacement of the fluid. Oxygen given intranasally lessened these rises.

The factor of hemorrhage also is not completely understood. In the severely injured or fatal cases it is not known how

much of the bleeding is the direct result of the trauma and how much is due to disturbed physiologic functions incidental to

reported cases of rapid death, apparently belonging to the concussion group, which seemed to be due to paralysis of the

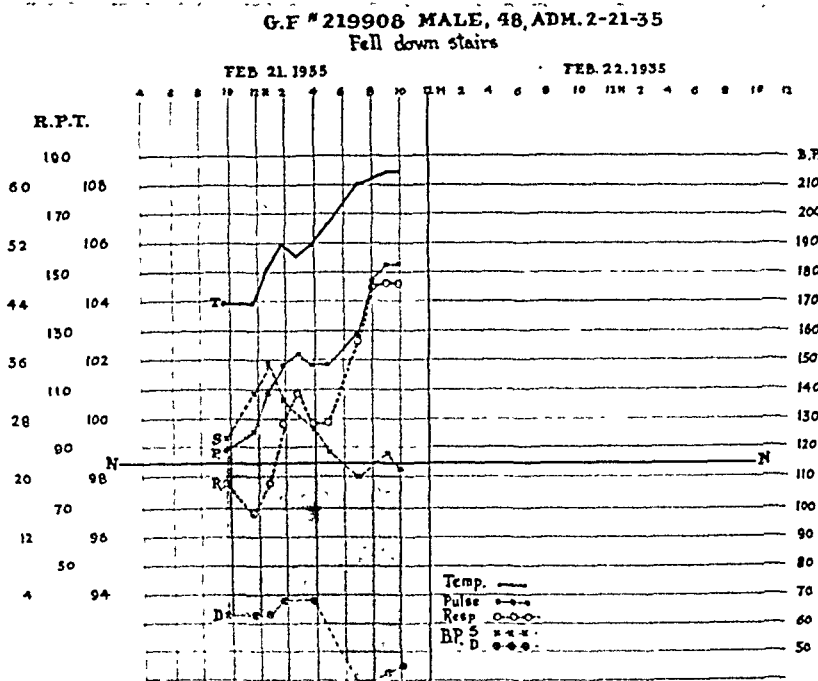


CHART I. The vital signs of a rapidly fatal case, in which death occurred due to a basal hemorrhage.

the treatment and terminal states. Nor is it definitely known whether or not spinal drainages are entirely beneficial in the presence of subarachnoid bleeding. A number of informative articles on this subject have appeared during late years, to which the reader is referred. Hemorrhage is of course by far the most serious complication of cerebral trauma and offers the greatest challenge to us all to find ways to lessen or control in the early stages. Promptly localized epidural and subdural hematomata often can be successfully treated surgically if there is not too much brain damage in addition.

Another important problem about which there is as yet no general agreement, is the accurate definition of the diagnostic terms concussion and contusion. Miller,<sup>26</sup> in an excellent summary of the theories of concussion, defined this as a transient state with immediate unconsciousness and with spontaneous recovery without sequelae. He

respiratory center. Forbes and Wolff<sup>27</sup> concluded from experiments on dogs that the cerebral circulation is in part at least controlled by cerebral vasomotor nerves. Schaller, Tamaki and Newman<sup>28</sup> reported eleven fatal cases and experimental data on albino rats all of which had died of petechial hemorrhages which were judged to have been caused by reflex vasomotor phenomena, and not by the direct action of the trauma.

These and other experiments on the vasomotor control of circulation may ultimately give us a more scientific explanation of the cases which show post-mortem diffuse punctate hemorrhages, apparently out of proportion to the severity of trauma. And this may force us to add another group in our clinical classification of cases.

From the above review, it is apparent that the results of brain trauma still present many unsolved problems,<sup>29</sup> which

challenge the best efforts of clinicians and scientists.

Regarding diagnosis, until some more

signs. Chart I illustrates a rapidly fatal case due to basal hemorrhage. Chart II is a rough diagram we use to show the average

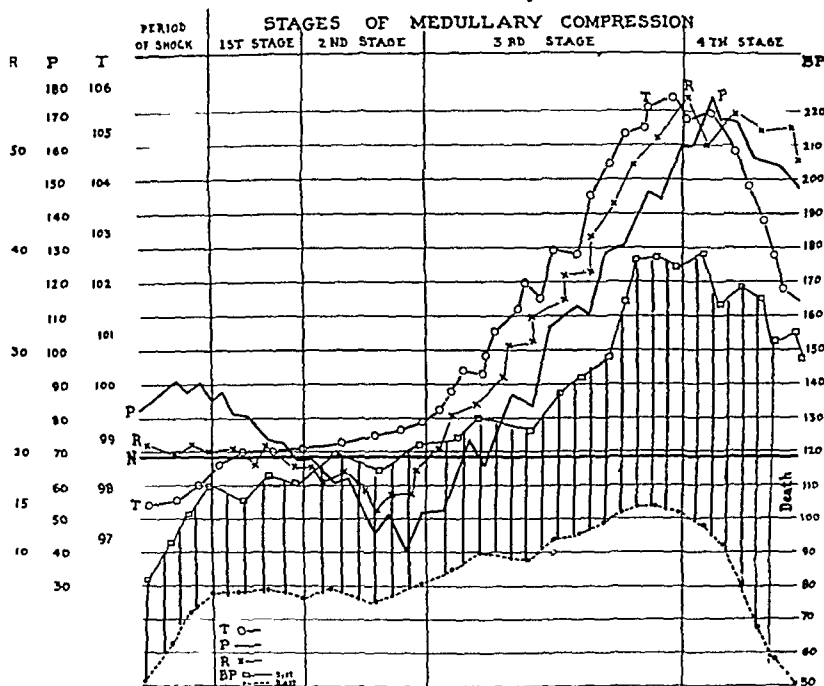


CHART II. A diagrammatic chart of averages of many fatal cases. The vital signs are shown during the period of shock and then traced through the four stages of medullary compression. Chronologically, the third and fourth stages may be much longer than shown here.

satisfactory classification is available, we shall continue to group our cases as concussion, contusion and laceration. Hemorrhage may accompany any of these three. With the latter two the brain may become swollen and engorged, depending upon the many variable factors mentioned above. Before one can safely evaluate a recently injured patient, one must insist upon obtaining full details of the mechanism and severity of trauma, the duration of primary unconsciousness. Also it must be determined early if there is probably a rapidly developing hemorrhage or if there is any condition requiring surgical interference so that effective appropriate treatment may be made available without delay, even though this may mean a careful transfer by ambulance to the nearest suitable hospital.

There are two sets of signs and symptoms to interpret, the medullary and the cerebral. In our teaching we spend considerable time emphasizing the medullary

course in fatal cases. It will be seen that the temperature and respirations usually change a little more promptly than the pulse and blood pressure. As has been pointed out by Browder and Meyers,<sup>30</sup> death occurs in some cases without showing these characteristic signs, but this represents the usual case. The important point to remember is, that if measures to relieve developing medullary compression are to be instituted, they must be done before the third stage develops with its stertorous, irregular or Cheyne-Stokes respiration, rapid, progressively weakening pulse and sharply rising temperature. These are evidences of beginning medullary failure and the resultant cerebral anoxia which in a few minutes will bring about hopeless or fatal destruction of cells. One must be on the alert, if anticipating possible middle meningeal bleeding, not to be lulled into a sense of security by the apparently favorable, full, bounding, slow pulse and the

slowed, deeper respirations of the fateful second stage. Here usually the temperature gives a helpful clue, and one is further because it thus masks important diagnostic signs. During the first few hours in a potentially

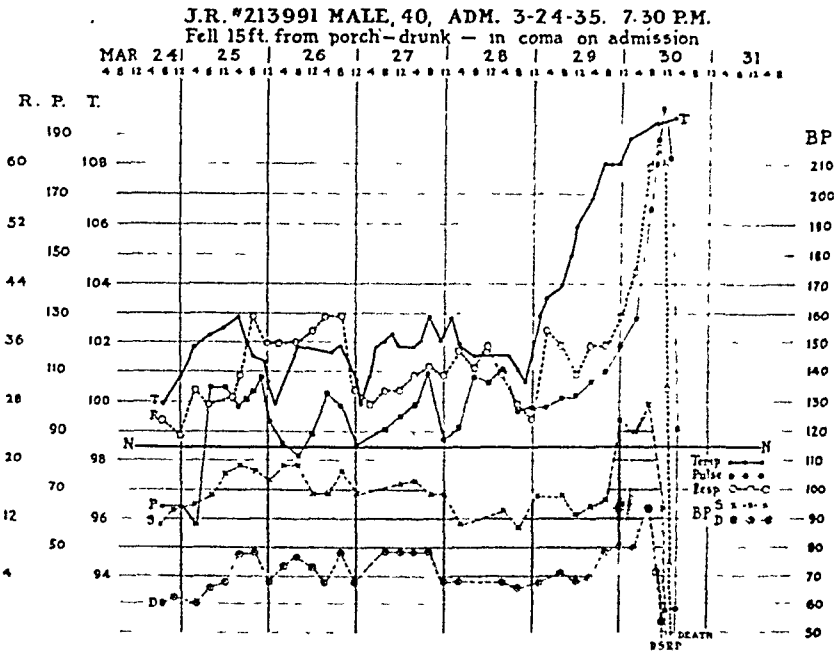


CHART III. An illustrative case of delayed death. In such cases the pathologic changes are mainly microscopic. Evidences of swelling, edema and gross hemorrhage may be absent.

informed by the cerebral signs of progressively deepening stupor (after the lucid interval of two to six hours), and the localizing sign of first constricting and soon dilating pupil on the side of hemorrhage. The muscle tone of the face and upper extremity and deep tendon reflexes on the opposite side complete the diagnosis. It is by frequent comparison of these various findings that one can best judge the course.

Chart III illustrates a common type of fatal case. Death occurs after several days, and often the pathologic findings after death do not seem severe enough to be incompatible with life. It is with this group of cases that we must strive for better results. Such conditions as toxic dehydration and hypoglycemia must be guarded against. Repeated arterial blood oxygen determinations should be done. Depression by drugs must be avoided. Morphine, especially, is undesirable because of its depressant action on the medullary centers and

serious case, frequent checks of vital and neurologic signs should be recorded by competent observers. Nurses can be taught to render valuable data if properly trained. During the examination one must remember the possible complicating presence of an accompanying injury to the chest or an intra-abdominal viscus, with its resultant profound shock. Gentleness of handling and avoidance of unnecessary exposure of the patient's body are important precautions. Spurling and Bradford<sup>31</sup> have given an excellent outline of neurologic diagnosis.

Management of the different types of cases was outlined in our previous communications.<sup>32,33</sup> A complete report on over 1200 cases is planned in the near future. We would stress again the importance of adequate treatment of shock, careful, thorough and prompt debridement of wounds, and the taking of x-rays when and if shock is past. All unconscious patients should be hospitalized at least one or two

days to be assured against slowly developing hemorrhage.

We institute oxygen therapy early in

point to remember if hypoglycemia exists. We combine sucrose and glucose according to conditions, and keep careful track of

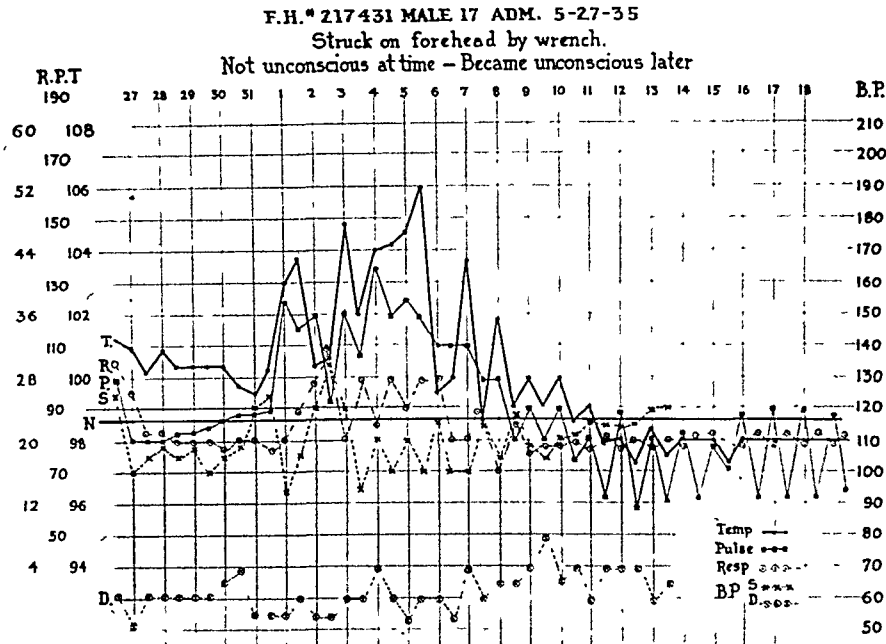


CHART IV. A case of delayed edema. Markedly relieved by strenuous dehydration régime of glucose, sucrose and lumbar punctures.

cases with persisting unconsciousness, particularly if the arterial blood oxygen is at all low. The normal blood oxygen saturation is 95 per cent. With levels below 85 per cent, the development of anoxia is speeded by such factors as hyperthermia, hypoglycemia, acute alcoholism, sedation by drugs and the progressive swelling, edema and hemorrhage of trauma. A preliminary communication regarding oxygen therapy in some of our cases has been made.<sup>34</sup> A more complete report awaits more experience. Measures advocated are to keep the blood oxygen and sugar levels as near to normal as possible to support the blood pressure at time of shock, and to avoid use of sedative and hypnotic drugs if at all possible. With the Hartman oxygen apparatus it is possible to keep the patient in as high oxygen atmosphere as desired (80 per cent to 100 per cent). It should be remembered that sucrose, while it is an effective dehydrating agent, may be toxic to some kidneys and is not utilized as nourishment by the tissues, an important

blood sugar during dehydration and of the urine when using sucrose.

Lumbar punctures give valuable data regarding intraspinal pressure and indicate the presence and amount of bleeding. They usually are not necessary or desirable until the stage of acute hemorrhage is past, but may then be helpful in removing blood from the subarachnoid spaces. They should not be done routinely in every case, but should rather be limited to cases which present generally accepted indications.<sup>20,33,39</sup>

We advocate and apply the principles of dehydration, in cases where edema develops as a complicating factor, but in our experience these cases occur relatively infrequently. Chart IV is of an illustrative case of effective results of repeated periodic use of glucose, sucrose and lumbar punctures. We have failed to see benefit from this procedure in cases where lacerations and hemorrhage were the main lesions. Our experience leads us to agree with Browder and Meyers<sup>47</sup> who state that intracranial tension is not the basic problem in the



management of craniocerebral trauma. We would also warn against the indiscriminate use of hypertonics.

In comatose or moribund patients, where the respirations are stertorous and pulmonary and laryngeal edema are beginning, pneumonia may be avoided if the foot of the bed is elevated and the face turned sideways and below the level of the trachea as advocated by Coleman.<sup>35</sup> In cases of persistent cerebrospinal drainage from ear or nose, in addition to operative closure of the defect in the dura, we administer sulfanilamide early as a preventative against meningitis. We have had some cases where this treatment apparently did prevent such a complication. For further details on therapy, the reader is referred to such articles as those of Munro,<sup>20,36,37,38</sup> Swift,<sup>40,41</sup> Craig,<sup>42</sup> Ney,<sup>43</sup> Battle,<sup>44</sup> Jackson, Dickerson and Gunther<sup>45</sup> and Mock.<sup>46</sup>

The surgical aspects of the problem are too extensive and specialized to be included here. Surgery is indicated in: (1) all compound fractures; (2) extradural hemorrhage; (3) depressed fractures, which should be operated on immediately if compound or if signs of compression are present, otherwise at a later date; (4) fractures resulting in cerebrospinal rhinorrhea; and (5) as a decompressive measure in a few cases where medical means have failed to prevent dangerous compression. (6) Subdural hemorrhages and hydroma can often be diagnosed only after exploratory trephines are made.

The end results, complications, sequelae and prognosis are problems which will be discussed fully in a subsequent communication. Suffice it to say, that although the immediate and end results have seemed to improve slightly from year to year, we should strive to save more patients from preventable deaths, to overcome where possible, in the early stages, the unfavorable processes which may result in slow death or in persistent unfavorable sequelae or even in permanent mental impairment. Also by attention to the psychic factors, we should try to avoid, where possible, the train of events which, in the predisposed,

so often leads to the development of psychoneuroses.

#### SUMMARY

1. The management of craniocerebral injuries in this country is becoming a problem of increasing importance.

2. Success depends upon a thorough working knowledge of the anatomy, physiology and pathology of the brain and the cellular changes caused by trauma.

3. Although there are still many unsolved problems, new data are accumulating which in time should place management on a more scientific basis with better results.

4. A pathologic process of great importance is the destructive cellular change which results from such conditions as anemia, hyperthermia, hypoglycemia, tissue swelling, shock, metabolic depression by hypnotic or sedative drugs and acute alcoholic intoxication.

5. Oxygen therapy, from our experience thus far, promptly increases diminished oxygen saturation in the blood. If used early enough and in sufficient concentration, 80 to 100 per cent, it may help to prevent the development of dangerous anoxia, particularly if the blood pressure is supported in shock.

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# TRAUMATIC INJURIES TO THE EYE AND ITS ADNEXA

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THE scope of this subject is so vast that consideration of each phase must of necessity be brief. Case reports and statistics have been purposely avoided. The material has been divided into separate headings and each part discussed by stressing the fundamentals from an ophthalmologic point of view, based on experience and observations made on cases in this clinic.

## INJURIES TO THE LIDS

Lacerations of the lids are often poorly repaired due to the minuteness of the anatomic structures and a lack of appreciation of the functions of this part of the eye.

Lids may be torn from either the outer or inner canthus and left hanging at one extremity or the other. This is particularly true of the upper lid. A line of tear at first vertical will often follow the retrotarsal fold across the lid. This indicates that the levator muscle has been disrupted and must first be sewed back to the posterior border before considering the orbicularis muscle and cutaneous structures. Adherence to this procedure will often prevent a permanent ptosis. The function of the lid appears lost at first but will gradually return.

The vertical portion of the laceration, as well as all other vertical tears or cuts wherever placed along the lid margin, must be closed, as Wheeler has proposed, by the "halving" method taken from the principles of carpentry. The tarsal plate must first be brought into exact alignment and coaptation. Sufficient paring of jagged edges to accomplish this may be done without fear of too much loss of substance. The orbicularis fibers and cutaneous structures are then lapped over this tarsal

plate closure, and reinforced by mattress sutures through all structures. This procedure will prevent many unsightly notches or colobomata which later require correction.

Injuries to the lower lid which involve the inner canthal region are very difficult to repair. Two conditions are likely to occur: (1) severing of the canaliculus; (2) retraction of the lower lid due to lack of proper coaptation of the laceration at this point.

A reunion of the canaliculus is an extremely difficult but not impossible task. This clinic has been very fortunate in accomplishing it in several cases. The repair is made by passing a number one Bowman probe through both the punctum and the portion of the canaliculus in the severed lid, then through that portion still attached to the lacrimal sac if it can be located. This holds the sectioned ends together until the lid repair is completed. Attempts have been made to do the so-called retrograde bouginage from the open tear sac but with very little success.

In order to avoid retraction of the lower lid due to poor coaptation of inner canthal tear, the tarsal plate must be reunited to the inferior portion of the tarsal ligament. Skin suturing alone will not suffice as relaxation will result.

In regard to skin closures in lacerations about the eye, emergency sutures are frequently very poorly applied. This probably happens because of insufficient training or instruction during the internship years. Too large suture material, too widely and too deeply placed sutures resulting in poor coaptation, and inadequately pared edges are the errors most often seen. Such work should be done over, if found early. Wounds about the eye, if deep, should be closed by suturing the subcutaneous tissue

with triple o catgut. The skin closure should be done with interrupted dermal sutures at close intervals and including the smallest amount of skin possible. Drains should be avoided.

#### INJURIES TO THE EXTRAOCULAR MUSCLES

Injuries to these muscles may be caused by objects penetrating the orbit or by fractures involving the apex. When such injuries occur, the function of the extraocular muscles should always be tested. Injury to the external rectus and to the inferior rectus has been encountered in separate cases. The torn bellies of these muscles are difficult to find, but there is much more difficulty if the wound is allowed to heal and the attempt made later.

The third, fourth, and sixth cranial nerves enter the orbit at the apex and may be injured by a fracture of that region. Paralytic muscles have resulted, causing compensation difficulties from a visual function standpoint. Consequently it is very important to repair muscles if possible at the time of the original injury. Paralyzed muscles resulting from nerve injury may receive plastic support from adjacent functioning muscles, giving sufficient aid to avoid obnoxious diplopia and loss of binocular vision. Paresis of a muscle has occurred from a simple blow to the globe and orbit. Recovery has taken place in one to three months in all such cases observed.

#### CONTUSIONS OF THE GLOBE

Since vision may be impaired by the quick snap of a rubber band as well as by a heavy pugilistic blow, all such injuries involving the globe should receive careful consideration. Intraocular hemorrhage usually occurs, but need not be present. It is necessary to recall that a contusion of the eyeball may produce any one or more of the following conditions: traumatic iritis with segmental paresis, dislocation of the lens, early cataractous changes, contusion of the retina at the point of keenest vision, tears of the retina

with resulting separation from the choroid, and tears of the retina and choroid without separation. This latter injury occurs most frequently about the optic disc, radiating outward. Invariably such lines of tear manage to cross entirely or partially between the disc and the macula, thus destroying central vision. The reason for this may be explained by the mechanism of a contrecoup blow plus the character of the retina in this region and the position of the macula. All of the conditions mentioned above require absolute bed rest and atropine until satisfactory examination of the eye can be made and the fear of a separated retina or dislocated lens is allayed. The best results in treatment of separated retina, however, have been obtained in the traumatic group.

#### PERFORATING WOUNDS OF THE GLOBE

Any puncture wound of the eyeball, however small, requires careful investigation and treatment. Some may be overlooked even with the most careful observation. The location of a perforation may be in the sclera, the limbus, or the cornea. Many involve both limbus and cornea.

Small wounds of the cornea are easy to miss without the aid of the slit-lamp. Simple indirect focal light, however, with some magnification before the observer's eye is often adequate. Although fluorescein is preferred, mercurochrome in any of its strengths makes a good stain and aids greatly in defining the extent of the injury. These small wounds are important because they frequently indicate the presence of a foreign body.

The limbus has long been considered a vital spot in injuries to the globe because of trauma to the underlying ciliary body, and because this area is regarded as the danger zone for sympathetic ophthalmia. It may be noted, however, that in the treatment of a great number of industrial cases in this clinic in the past twenty years, no cases of sympathetic ophthalmia

due to trauma of the ciliary body have been encountered.

Perforations of the sclera may be easily

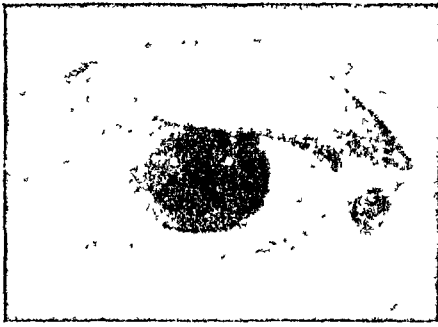


FIG. 1. Poor lid repair.

obscured by conjunctival hemorrhage, but early recognition of these wounds enables one to take proper precautions against detachment of the retina. A careful fundus examination is always necessary. The presence of blood in the vitreous may indicate a perforation or a foreign body. The x-ray should be resorted to in all such instances not only to help determine the presence of a foreign body but also to protect the surgeon in case of medicolegal difficulties.

Rupture of the eyeball as a result of a severe contusion is not unusual. The lens has been found nicely extracted and lying under the conjunctiva. Regardless of the cause of injury, many of these wounds heal by first intention after masterful inactivity on the part of both the patient and the surgeon.

Prolapsed iris must always be removed from corneal wounds and should not be tucked back into the anterior chamber. It probably would not remain there and furthermore it may carry infection back with it. Suturing of corneal wounds is practiced by some surgeons but requires skill and special instruments. Unless one is so equipped, less trauma will result by using a conjunctival flap or the closed lids as a splint. A badly injured eye is easily made worse by too much manipulation. One should not be too hasty in advising removal of an eye, for vision of  $20/30$  or better has been obtained in what looked

like a hopeless eye. Both surgeon and patient should have a few days' leeway to consider such an important step.

Should the removal of the eye become necessary, the surgeon should be governed in his choice of operation by the presence of acute infection or a prolonged low grade chronic inflammatory state. Although traditional ophthalmologic teaching recommends evisceration for the first and enucleation for the second of these conditions, we have used evisceration almost exclusively without extending infection or aggravating the production of sympathetic ophthalmia. There is no question but that the cosmetic results following evisceration with glass or gold ball implant in the sclera are superior to those following enucleation and ball implant into Tenon's capsule. Mucus, which is a great annoyance to patients, often collects on the prosthesis after enucleation while no such condition has been found to follow evisceration. The use of rib cartilage as an autogenous implant was used for a time in this clinic, but it added nothing to the function of the socket and its use has therefore been abandoned.

#### TRAUMATIC CATARACTS

Injury to the lens occurs frequently with trauma to the globe. The formation of a cataract, if sufficient to cause loss of vision, is compensable in most states, whether it is removed or not. Most industrial organizations are very willing to have everything possible done for such patients. Consequently cataract surgery is performed whenever indicated.

The diagnosis of traumatic cataract is not difficult. Occasionally, however, a medicolegal complication arises where it is necessary to give an opinion as to the type of cataract present. A careful study of the opposite lens should be made for similar markings, whether nuclear, cortical or capsular, in order to rule out congenital abnormalities. It must be remembered that contusion cataracts may arise without a break in the coats of the eye, therefore a

diligent search for capsular scars and associated cortical changes must be made. The capsule may close or be plugged by

large a piece of the anterior capsule as possible at the time of removal of the lens material. If the anterior vitreous has been

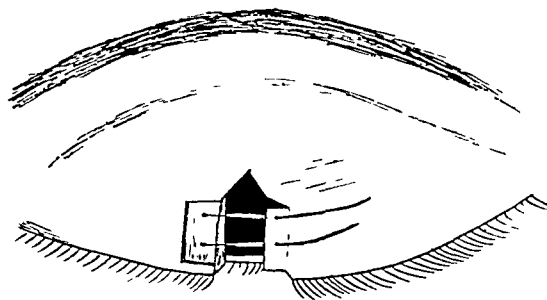


FIG. 2. Wheeler halving operation in lid repair.

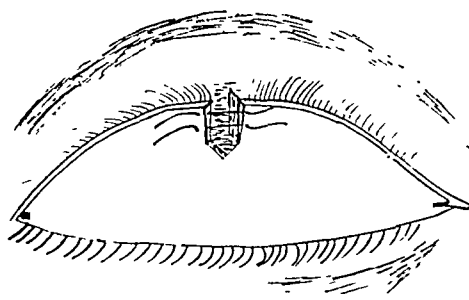


FIG. 3. Placing of sutures in the tarsal plate in the Wheeler operation.

cortical substance so that further entrance of aqueous is blocked and extension of the process in the lens substance stopped. Should this be in an eccentric position, fairly good vision will be maintained for an indefinite time. Here prognosis should be guarded for complete cataract may develop at some future time. Foreign bodies in the lens are discussed elsewhere.

Dislocation of the lens is not unusual. They may be partial or complete. When the latter occurs they are either in the vitreous, the anterior chamber, or outside under the conjunctiva. Dislocations within the globe mean secondary glaucoma sooner or later and because of this, removal is indicated before such a complication arises. Dislocated lenses become cataracts.

Cataracts, arising from puncture wounds in the anterior segment of the eye, usually progress quickly because of a considerable rupture of the capsule with exposure of the cortical substance to the aqueous fluid. These lenses swell rapidly which brings up the question of their immediate removal. If lens substance is not present in the aqueous, removal may be delayed until the general reaction of the eye subsides. The possibility of secondary glaucoma must be kept in mind. If there is considerable exposure of lens material, as much of it as possible is removed by physiologic saline irrigation. One must try to avoid the development of a thickened capsule which is difficult to remove except with scissors. It is therefore a good thing to remove as

ruptured at the time of injury, it is preferable to wait, if possible, before removing lens substance in order to avoid loss of vitreous.

Age is a factor in deciding upon the type of operation to be used. The nucleus in the lens of an adult is quite firm and in most cases the cataract is best removed by the capsulotomy method employed for senile cataract extraction.

Due to the inequality of images, glasses are not prescribed for these patients except occasionally when requests are made in order to obtain employment.

#### INTRAOCULAR FOREIGN BODIES

The literature is voluminous on the subject of intraocular foreign bodies, their complications and methods for their removal. There is a paucity of records on visual results, because most of these injuries occur in industry to transient employees and final records are difficult to obtain. Because of the compensation laws, such records are necessary and valuable for reference.

In studying a foreign body case, the following questions present themselves: (1) What kind and of what character is it? (2) What structures has it entered; what damage has been done, and where is it located? (3) What is the present status of vision? (4) How shall it be removed?

1. The history will help to determine the kind of substance of which the foreign body

may be composed. The place, the tools, the machines used by the patient, also by those near by in case of flying chips, the

3. The status of the vision on admission to office or hospital is essential for both medical and legal purposes. The exact

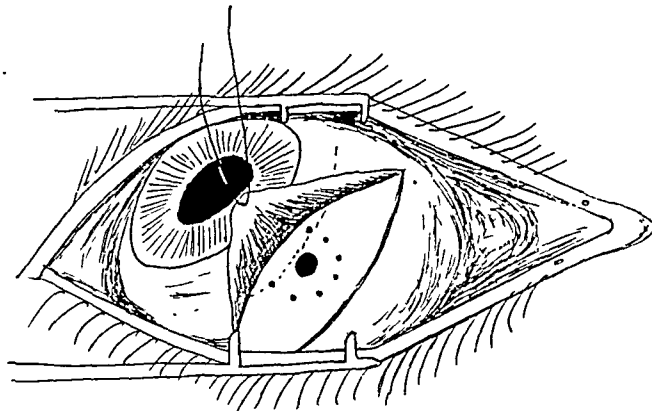


FIG. 4. Electrocoagulation with trephine opening in the center for posterior route extraction of the intraocular foreign body.

type of metal, whether magnetic or not, and the time the accident occurred, give valuable information.

2. The use of the slit-lamp is very valuable in determining the place of entry to the eye and in the search of the anterior segment area for the foreign body. Transillumination of the globe aids in locating a hole in the iris and must not be overlooked. A careful survey of the entire lens is essential. A wide dilatation of the pupil will be necessary for this procedure; however, it is assumed that the anterior surface of the iris and angle have been examined before this is done. The course of the foreign body may be seen by a survey of the vitreous unless it has been obstructed by cataract or blood. When seen with the ophthalmoscope a metallic foreign body will appear black and shiny, not unlike a piece of coal. A survey of the retina is important, as the foreign body may be seen sticking in it or else the puncture wound of exit into the coats beyond may be found.

Localization plates are always made even though the foreign body may be seen. This is important alike for legal purposes and to aid the surgeon in knowing the size and position of the object. Haste in such cases is not essential and adequate time should be taken to study the conditions carefully before attempting the removal.

amount of vision and the preservation of vision are two points of great importance.

4. The method of removal is determined by the findings. If the foreign body is in the anterior segment of the eye, i.e., in the ciliary body, lens, iris, or anterior chamber, the anterior route is used. Cataracts may be produced by bringing a jagged piece of metal forward from the vitreous. If there already is a cataract, this route is used from the vitreous. Otherwise all posterior segment foreign bodies are removed by the posterior route.

It is interesting to note that since the advent of the electrocoagulation instrument, only one detachment of the retina has occurred and that was due to an early variation in the use of this method. The method is described as follows: A barrage of micropin coagulations is set up around the point where a 2 mm. trephine opening is to be made. Then the foreign body is extracted through the opening. If the piece of metal has been calculated to be larger than 2 mm., the opening is enlarged with a Von Graefe knife. The inferior nasal quadrant near the ora serrata is usually the site selected. It is believed that detachment of retina, as a complication of intraocular foreign bodies, may arise from other causes than the exit made for the extraction.

Care in the use of the electric magnet is important. It is not used as a diagnostic agent unless necessary. Under the direct

through the sclera much as one attempts to approximate the position of a tear in the retina.



FIG. 5. Hypopyon following intra-ocular foreign body.

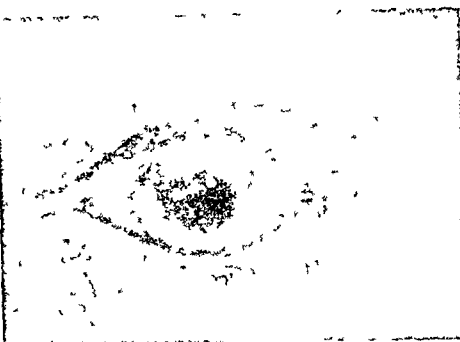


FIG. 6. The eye twenty-four hours later, following fever therapy in the Kettering hypertherm cabinet.

vision of the ophthalmoscope, it may be gently used to test small clots of blood in the vitreous for movement or for magnetic properties of the foreign body. X-ray localization always precedes the use of the magnet. It must be emphasized however, that the x-rays have erred both in localization and in suggesting the presence of a foreign body. By repeating the x-ray after an unsuccessful application of the magnet, a shift in position may often be found. Do not attempt operative procedure after using a magnet until another x-ray is made. Experience has proved that application of the magnet repeated at several day intervals is important if there is suspicion that the body is magnetic. A Sweet hand magnet is preferred and used first, as undue magnetic force can do much harm to the anterior segment of the eye. The giant ring magnet of Professor Mellinger of Basle, made by Weis of London, which is used in this clinic, permits the patient to lie down for its application and allows more freedom of movement of the magnet tip.

Foreign bodies lodged in the retina and choroid have been observed to produce detachment of the retina and degeneration of the eye. By observing the movement of a foreign body in the retina under the action of a magnet, it is easily understandable why it is so difficult to remove the foreign body without damaging trauma. It is better to attempt to remove the metal

The lens tolerates surprisingly the presence of foreign bodies from the standpoint of irritating the anterior segment of the eye, as these seem to encapsulate themselves and remain for indefinite periods without producing complete cataract. Therefore there is no need of haste in removing them. Several such cases are under observation at the present time. There are some who advocate removal of these pieces of metal at once with equally good visual results. If it is evident that a cataract is developing, then it is best to proceed at once with the extraction of the metal, for there will be less autolysis of lens substance and toxic effects upon the anterior segment of the eye.

Foreign bodies may remain in the eye for years, as many records attest, without destroying the eye. Oxidation of a piece of metal has been known to take place, leaving no residue—while on the other hand reactions may take place early with rapid loss of the eye. Some eyes have been much worse after removal of the foreign body. Especially is this true of the non-magnetic group of metals, stone, glass, etc. On the whole, however, experience has shown that the best treatment is to remove the foreign body early, if at all possible.

#### FEVER THERAPY IN TRAUMATIC INJURIES OF THE EYE

The practice in this clinic has been to give foreign protein to every patient with a



penetrating wound of the globe or a severe traumatic ulcer of the cornea. All the prevailing types have been used for typhoid H-antigen is preferred because of the ease of administration and lack of sequelae. The dosage has ranged from 25,000,000 to 100,000,000 bacilli, depending on the individual case. The fever thus induced ranges from 100° to 102°F. This has not been considered quite sufficient, but higher dosage has not been used because of the possibility of grave systemic reactions. Just how valuable this form of treatment may be is difficult to determine. Some penetrating wounds do not develop infection anyway. It is questionable whether corneal ulcers are arrested by its use. Panophthalmitis and endophthalmitis have not been stopped. Because of the work of Dr. Albert L. Brown which showed a definite increase of the antibody content in the aqueous fluid following the use of typhoid antigen it has seemed advisable and necessary to administer it at the outset of all such cases.

Fever produced by the Kettering hypertherm cabinet has been extensively used by the Division of Ophthalmology. A fever of 105° to 106°F. for four to five hours, repeated as desired every three to seven days, has been the procedure. The results of its application for exogenous infections of the eye have been disappointing. A hypopyon of the anterior chamber has disappeared in twenty-four hours and the congestion of the eye has improved, but practically every infection carried into the vitreous of the eye went on eventually to a low grade endophthalmitis or to phthisis bulbi. A few patients still retain their sightless eyes and they appear quiet. No sympathetic ophthalmia has developed during or following this therapy. Whether this type of fever has any influence on this dreaded disease has not been answered. Some cases of corneal ulcers were arrested by its use, however, other standard treatment was being given at the same time. The use of fever therapy in certain endogenous infectious or allergic

manifestations in the eye has been found to be definitely valuable, but it is not within the scope of this paper.

#### BURNS OF THE EYE

There is much room for improvement in the management of burns of the globe, whether thermal, acid, or alkali. Experimental work on burns in this clinic has demonstrated that free washing of the eye with water should precede the use of neutralizing agents. The results from 5 per cent tannic acid, mixed with water, glycerin, or an antiseptic ointment, have been disappointing. Because of its beneficial effect on the skin of the lids and the face, it was hoped that at least in alkali burns it would be of value.

In lime burns 5 per cent ammonium chloride has been at least as effective as 10 per cent ammonium tartrate. Trisodium citrate 8 per cent has not proved to be so effective as the ammonium salts. Since lime burns are not washed away to any degree by water, gently scraping away the lime deposits has been found to be very effective, thus preventing further chemical action upon the tissues.

Ammonia burns are considered the most severe. While much is said about the delayed reactions being due to the penetration of ammonia through the cornea, animal experimentation with chemical analysis of the aqueous has not borne out this statement.

Burns involving the sclera and limbus, if of second or third degree, are likely to produce sloughing of the adjacent cornea, due probably to the lack of nutrition from the injured loops of limbal vessels. Conjunctival or mucous membrane grafts, as advised by Denig for the scleral limbal area, are advocated and appear to provide a source of nutrition and an aid to corneal conservation. Tannic acid will provide a coagulum in this area, yet it does not prevent the breaking down of the cornea.

Applications of ointment and free manipulation of the lids daily with a glass rod still seems to be as good a method as any

yet found to prevent adhesions, although cellophane and thin rubber dam have been tried. Mucous membrane grafts continue to be used for adhesions of the lids to the globe as skin grafts are not very satisfactory in this region.

#### FRACTURES OF THE ORBIT

Fractures involving the bony structures of the orbit have become increasingly important since the majority are due to automobile and airplane accidents as well as to direct blows with fists. Fractures of the orbit are significant when viewed in the light of their relation to basal skull fractures with possible injury to the cerebral mass, along with the close relationship and likely trauma to the globe. Orbital fractures in our experience are generally due to direct blows with extension of the fracture lines into the bony orbit. The bones involved in order of frequency are: the zygoma; superior maxilla; frontal bone; lamina papyracea of the ethmoid; and the lacrimal bone, while injury of sphenoid and palate are quite infrequent.

The fact that the malar bone makes up a large portion of the floor and lateral wall, as well as the inferior and lateral margin of the orbit, and forms the prominence of the cheek, accounts for the frequency of fracture. Fracture lines may run into the frontal and maxillary sinuses. Displacement is in the direction of force which is generally downward and backward with rotation on its own axis. If fractures extend into the antrum, there is apt to be epistaxis with subsequent danger of infection. If there is enough displacement, ocular complications such as subconjunctival hemorrhage, orbital hemorrhage with decreased motility of the globe, displacement of the globe with diplopia and emphysema, may result. Involvement of the infraorbital nerve is not infrequent.

Diagnosis in fractures of the malar bone and maxilla hinges essentially on inspection, palpation, comparison with the opposite orbital rim, and the roentgenogram. Treatment is early reduction, unless swell-

ing has progressed to the extent of interference, in which case proper treatment includes waiting for the swelling to subside before reduction is attempted. Although every case is individualized, the method of reduction here centers around the Caldwell-Luc approach. After reduction, the antrum is firmly packed, the buccal incision is closed and an antromental window is made for drainage. Any loose fragments of bone and all blood clots are removed. If malocclusion is present, close coöperation with the oral surgeon is essential.

Fractures of the frontal bone generally involve the frontal sinus and here there are the added dangers of intracranial injury and infection. Ocular complications, such as ecchymosis of the conjunctiva, orbital hemorrhage with decreased motility and exophthalmos, emphysema of the lids and orbital contents, enophthalmos, sudden blindness, corneal wounds, dislocation of the lens, traumatic mydriasis, iridodialysis, intraocular hemorrhage, lesions of the choroid, and detachment and rupture of the retina, are frequent. Treatment of a fracture involving the frontal bone includes the close coöperation and services of the neurosurgeon. If an external wound is present and the inner wall is not damaged, the external wound is closed after establishing adequate drainage by way of the nasofrontal duct. If the inner wall is damaged, the external wound is made larger and, if depressed, the fragment is elevated; if there is an opening in the inner wall it is enlarged and the dura exposed; if the dura is torn it is repaired with a free graft of fascia lata. In these latter conditions external drainage is preferable and contact between the nose and sinus cavity must be prevented.

Fractures of the lamina papyracea of the ethmoid are generally due to perforating injuries. They are associated with epistaxis, orbital hemorrhage and emphysema. Conservative and expectant treatment is generally all that is necessary, along with thorough cleansing of the outer wound and nasal cavities. The same holds true for

fractures of the lacrimal, sphenoid and palate bones. In these, complications such as sudden blindness due to hemorrhage into the sheath of the optic nerve or injury to this structure by a fracture through the optic foramen may result, as well as injury to the lacrimal sac or nasolacrimal duct.

#### SUMMARY

1. Restoration of proper function and appearance of the lids after injury, requires a knowledge of the anatomy and physiology of the parts and of the fundamental principles of plastic surgery. Many emergency operations are poorly done.

2. The extraocular muscles themselves are rarely injured but their functions are often disturbed by contusion of the nerve supply, fractures and lacerations.

3. Contusions of the globe, however simple, often prove serious to sight; therefore every eyeball so injured should receive careful scrutiny both inside and out.

4. The importance of detection of minute perforations of the globe is emphasized because of their aid in detecting possible intraocular foreign bodies. Bed rest and careful observation for complications in all perforating wounds of the globe are indicated. Sympathetic ophthalmia has not developed in this group.

5. Traumatic cataracts may arise from contusions as well as from penetrating wounds of the globe and should be removed

at the proper time, provided the posterior segment of the eye is intact.

6. Intraocular foreign bodies may or may not prove serious to sight; their character and location plus the element of infection are the determining factors. All foreign bodies should be removed as soon as detected whenever possible. Sometimes, however, haste makes waste and should be avoided.

7. Injection of foreign protein in some form to produce fever and stimulate antibody formation is widely used in the practice of ophthalmology. The amount of fever produced seems to be the criterion of its effectiveness. Typhoid H-antigen is generally preferred for prophylactic purposes, although its exact value is difficult to judge. Induced fever by the use of the Kettering hypertherm cabinet does not destroy exogenous intraocular infection.

8. Second and third degree burns of the eye are destructive to sight and disappointing to treat. Research investigation so far has contributed little to improvement in method of treatment.

9. Fractures of the malar bone and zygomatic arch are the most disfiguring and may produce binocular imbalance and asymmetry of the eyes. Intraocular damage is also a possibility. Repair should be done if possible before swelling occurs or immediately after it subsides. The Caldwell-Luc operation is the method of approach mostly employed. Fractures of the optic foramen may produce optic atrophy.



# FRACTURES AND DISLOCATIONS OF THE CERVICAL SPINE

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THE recent revival of interest in the treatment of injuries of the spine has resulted from recognition that the adequate reduction of the displacement often leads to complete cure or at any rate to marked reduction in the residual disability. This has proved as important in the injuries of the cervical region as in those occurring elsewhere, for aside from those injuries produced by the hangman's knot, the spinal cord is often not seriously injured and is frequently capable of recovery if the displacement is reduced.

Hospital practice and experience in these injuries must vary greatly with the character of the community served and with the qualifications of the staff. Thus, the orthopedic service is likely to see many patients whose complaints are chiefly pain, deformity and stiffness of the neck, whereas the neurosurgical department will see others who have varying degrees of involvement of the nervous system. The combined opinion of these two departments in this hospital, however, based on observations extending over ten years, is that most of the cases that are brought to the hospital alive have no, or only slight injury to the cord and that even many of those with signs of a cord lesion may be expected to show progressive recovery when the pressure on the cord has been relieved.<sup>1</sup>

It is not the function of a symposium such as this to deal with the subject as in a textbook, but it is rather to draw attention to ideas that are new and to viewpoints that have changed. I shall say nothing, therefore, in regard to the anatomy, the etiology and the diagnosis except to point out that any patient who has had an injury of the neck and who continues to complain of pain or stiffness or who holds his head in

a peculiar attitude, should be submitted to x-ray examination. The x-ray may show a forward dislocation of a vertebra with or without fractures of the anterior lips of the bodies or fractures of the pedicles or articular processes. The commonest lesion is a forward dislocation of the inferior articular facets of the upper vertebra over the tops of the upper articular facets of the lower.

The outstanding impressions left by our experience with such cases are these:

1. The reduction of the displacement is imperative, for although no neurological signs may be present at the time, they are altogether likely to develop later, either as the result of further sudden displacement or of more gradual displacement caused by the weight of the head.

2. It is imperative also because when such patients again assume the upright position, even if they have no cord signs, they have intolerable pain in the neck and in the distribution of the spinal nerves which leave the spinal column in the neighborhood of the injury.

3. Efforts to reduce the dislocations by manipulation are attended by such appalling risk of damage to the spinal cord that they should not be employed. I saw one such disaster and it was enough.

4. The successful reduction of the dislocation by no means ensures that it will not recur, for it frequently does so as soon as the patient sits up and in spite of splints, collars and plaster jackets. Further, it may recur weeks or months after the reduction, particularly in cases in which this was obtained a week or two after the injury. In such cases the torn or avulsed ligaments have not had a chance to heal properly and so remain permanently weak.

5. Reduction of the displacement in most cases can be accomplished with complete safety by the use of skeletal traction applied to the head.

the muscles of respiration by pressure or edema ascending to involve the third and fourth cervical cord segments, the Drinker respirator may be used. Respirations can



FIG. 1. Patient suffering from fracture dislocation of the fifth on the sixth cervical vertebra. He has been anesthetized and submitted to heavy traction with tongs preparatory to application of plaster jacket.

6. In those cases in which reduction cannot be accomplished with skeletal traction because of the locking of the articular facets, an open operation which exposes the facets enables the surgeon to disengage the locked processes under direct vision and without risk of damaging the cord.

7. Recurrence of the displacement after such operative reduction can be guarded against by fastening the two vertebrae together by fine steel wire passed around the laminae or spines. And the risk of late recurrence can be eliminated by bone grafts laid in the spines or on the laminae and articular facets.

8. Skeletal traction alone or in combination with operative exposure of the dislocated articular facets will accomplish reduction months or years after the injury and when combined with successful fusion of the adjacent vertebrae will give permanent results.

9. In those patients who are having respiratory difficulty from paralysis of

be maintained until recovery of cord function develops after reduction of the displacement.

The importance and feasibility of reduction of the displacement in fractures and dislocations of the spine has only recently impressed itself on us. The practice in this hospital, as in most others, has been to leave the displacement alone for fear of doing greater harm in those cases without neurological signs and to relieve possible pressure by laminectomy in those in which paralysis was a feature. The demonstration by Davis,<sup>3</sup> however, that compression fractures could easily be straightened out without risk has caused much speculation as to whether similar methods might not be applied to more serious displacements and even those in which there is an associated injury of the cord. One cannot but be impressed with the comparative futility of laminectomies done to relieve pressure on an injured cord where no measures are taken to reduce displacements of the

vertebrae and nothing done to get rid of the gross distortion of the spinal canal. One cannot forget also the almost inevitable

skin and to reach the skull. The points are then engaged in the bone by a light sharp tap with a hammer and the handles locked.

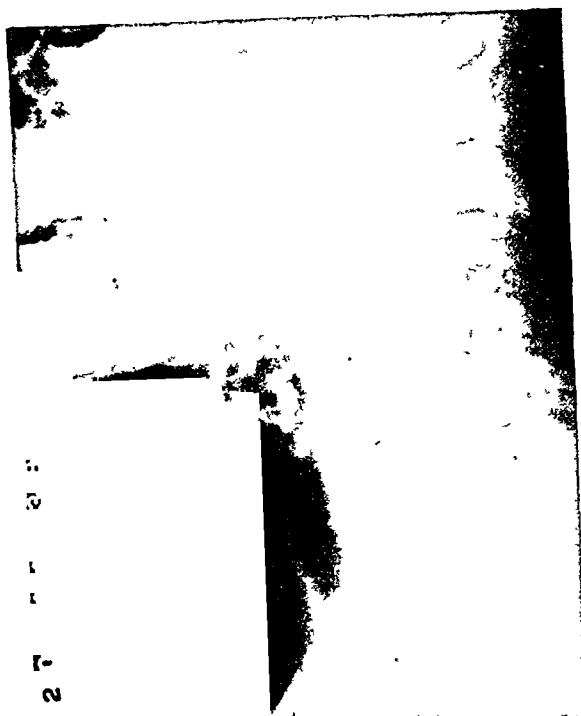


FIG. 2. Roentgenogram of patient with gross forward dislocation and slight crush fracture of cervical vertebrae.

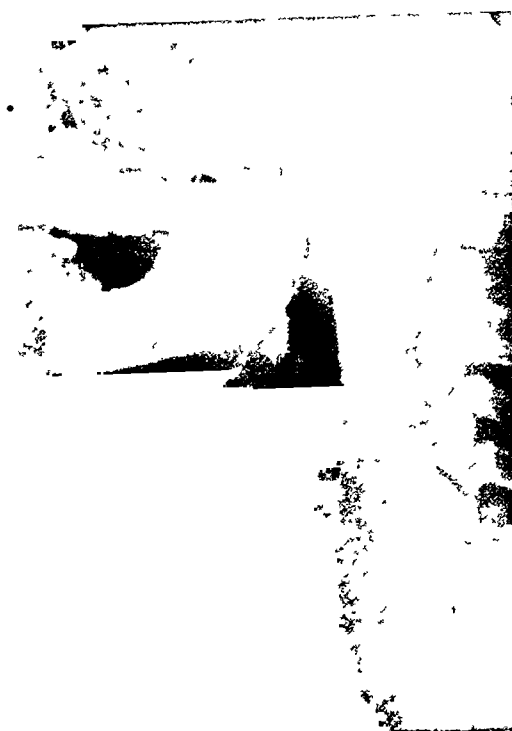


FIG. 3. Same patient ten weeks later, after complete reduction of the displacement by skeletal traction. Note the bridge of new bone fusing the anterior border of the injured bones.

increase in the deformity, usually a kyphosis, that will occur when the patient again assumes an upright attitude.

The application of the principle of skeletal traction to the fractures and dislocations occurring in the cervical region has solved many of the difficulties. With the traction applied directly to the head by means of tongs, hooks or wires, it is possible to reduce the displacement painlessly and safely, to get rid of the compression of the cord without laminectomy, and to restore the smooth continuity of the spinal canal.

The technique employed in this hospital<sup>2</sup> is best illustrated in Figure 1. As soon as the diagnosis is made, either from neurological signs or from physical examination of the neck and from x-rays, tongs are fastened into the skull and heavy traction applied. A small area of skin just below the most prominent part of each parietal bone is shaved and cleansed and the area anesthetized with novocaine. Tiny incisions allow the points of the tongs to traverse the

The lock prevents the points from becoming disengaged from the skull or from sinking too deeply into it.

The advantage of skeletal traction over older methods such as traction with the leather chin cup halter, is great. It is painless and comfortable, and as in the case of skeletal traction applied to the extremities, effective. Now that it has been shown from experience with scores of cases that it is safe there is no doubt it will replace all other methods of applying traction.

The subsequent management will depend on the presence or absence of signs of injury of the cord.

Thus, if high cord injury is present, such as might accompany injury of the odontoid process or third cervical vertebra, the indications are to reduce the displacement and to arrange for artificial respiration until a sufficient degree of recovery has been established to enable the patient to

breathe by himself. This has been accomplished in this hospital by my colleague, Dr. E. H. Botterell, who placed the patient in the Drinker respirator apparatus and maintained constant traction on the head and neck by means of tongs.

In cases of injury to the cervical spine below the level of the fourth vertebra, in which there has been injury to the cord, the tongs are applied and the patient put to bed on his back with the head hanging over the upper edge of the mattress or a pillow. This ensures reduction of the displacement and prevention of its recurrence and it allows, without much risk, the frequent turning of the patient which is necessary to prevent the onset of bedsores. In such cases very narrow tongs or the special tongs described by Crutchfield<sup>4</sup> which are narrower than the head, are preferable, as they do not interfere with the turning of the patient.

The third group, which in our experience is by far the most numerous, is composed of cases of forward dislocation or fracture-dislocation of the fourth, fifth, sixth or seventh vertebrae and without serious injury to the cord. These cases are at once put on the special apparatus illustrated in Figure 1, the displacement completely corrected by heavy traction, up to 30 or 35 pounds, and by raising or lowering the chest and head to make sure that the traction and leverage are in the proper direction. When the x-ray shows complete reduction a plaster Minerva jacket extending from crown to pelvis is applied. The tongs are then removed. (Figs. 1, 2 and 3.)

An outstanding feature of the subsequent history of all types of fracture dislocation of the cervical spine is the tendency to recurrence of the deformity. This is particularly the case in patients in whom there has been a forward dislocation combined with a crush fracture of the anterior edge of the vertebral body below the dislocation, and in those in whom there has been a fracture of the articular processes. It is prone to occur, however, even in those in whom the forward dislocation is uncomplicated by fracture and on the slightest provocation.

Thus it will occur while the patient is lying flat on his back if he raises his head to the slightest degree even when the traction is still on, so that it is necessary to maintain the backward bowing of the neck at all times to guard against slipping. It will occur almost every time in a Minerva jacket if this extends downward only to the middle of the chest and will occur also in jackets extending to the pelvis unless these are perfectly applied. Another disturbing observation is that even in cases in which the dislocation has been reduced perfectly and the position maintained for several weeks, a gradual slipping may develop later which may go on to the production of local pain and stiffness and even of signs of involvement of the cord. This seems particularly likely to happen in cases in which the primary reduction has been delayed or in which considerable time has been lost in the correction of recurrences. It probably results from failure of the ruptured ligaments to heal properly before strain is applied.

This strong tendency to recurrence of the deformity has attracted very general attention and has led us, along with others, to resort to operative measures to prevent it. Thus we have on several occasions exposed the spines of the two vertebrae involved and fastened them together with fine stainless steel wire. With this we have sometimes combined measures to ensure fusion of the adjacent articular facets and laminae by the Hibb's method or of the spines by the introduction of an Albee graft. A successful fusion eliminates the possibility of late slipping.

We have been so impressed with the tendency to recurrence that we now consider seriously in every case whether or not an operation should be done. There is no doubt that it is not necessary in all cases but as time goes on we find that we are wiring and fusing more and more. The importance of this is emphasized by Cone and Turner.<sup>5</sup> Our present plan is to submit to such an operation all cases in which our experience has taught us that slipping is likely to occur and all cases in which a

tendency to slip has revealed itself while other methods are being employed.

In addition to cases suffering from recent fractures and dislocations there has been a number of cases admitted to hospital weeks and months after the injury, in which the displacement has never been reduced or in which it has recurred. These all require operative treatment. In the early days of skeletal traction we found that sometimes it was possible, even months after the injury, to reduce a gross displacement by heavy traction. This always recurred, however, as soon as the traction or the plaster jacket was removed. In many cases, on the other hand, heavy traction failed to disengage locked articular processes, so that it became necessary to expose these processes in order to unlock them. We have usually had to clip off the upper edge of the superior articular facet of the lower vertebra to enable us to lever the inferior processes of the upper vertebra into place. A skilled hand manipulating the head at this stage is very helpful. Once the deformity has been reduced the adjacent spines should be fastened together with steel wire and measures taken to fuse the laminae and facets on the spines. If it was necessary to expose the articular facets the cartilage should be removed from them with a curette and some chips and slivers of bone, obtained from the leg or ilium, so laid on the freshened surfaces as to bridge the articular processes and laminae. If such deep exposure was not necessary a simple single or double graft tied into the spines will be sufficient.

In cervical injuries with associated cord damage, as in spinal injuries elsewhere, the complications most feared are bladder infection and bedsores. These, however, can be minimized greatly if certain precautions are taken.

The most effective way to prevent infection of the paralyzed bladder or to clear up the infection if it is already established is to introduce the tidal irrigator described by Munro.<sup>6</sup> In our experience this has been spectacularly successful and if a little care and patience are exercised at the beginning

it can soon be turned over to the management of the patient himself. It has solved one of the most miserable accompaniments of fracture of the spine.

The prevention of bedsores in the sacral region depends on keeping the parts clean and dry and on frequent changing of the patient's position so as to take the pressure off the area. With skeletal traction this can be done safely and is one of the chief reasons for continuing the traction after the primary reduction has been made. The only precaution necessary is to avoid gross displacement of the head when the patient is being turned. In those cases in which traction is to be maintained for a long time the weight should be reduced to 8 or 10 pounds as soon as reduction is complete, as it has been found that heavier traction maintained for twelve hours or more may produce paralysis and anesthesia in the arms. During the turning movements the weights may be increased temporarily to 15 pounds.

A retrospect of our experience of the past ten years has led us to a decidedly more hopeful view of the prognosis. As far as those cases are concerned that are uncomplicated by cord injury there is no reason whatever to anticipate anything but complete cure. Involvement of the cord is of course serious but even when this is present it is often possible for recovery to take place if the deformity is reduced and if the patient can be kept from dying in the early stages from respiratory failure or urinary infection. Laminectomy still has its place where fragments of bone are compressing the cord but in many instances skeletal traction aided by the Drinker respirator and the tidal irrigator is preferable and gives the patient a much increased chance of recovery.

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# THE FASCIAL SPACES OF THE NECK IN ACUTE INFECTION\*

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**A**LTHOUGH the importance of fascial planes in acute infections of the extremities is well understood by most physicians, the relation of the spread of infection in the cervical region to the fascial architecture is much less appreciated. The course of infections of the neck is determined by definite fascial planes that may act as barriers to localize infection or may direct the spread of an acute suppurative process to involve fascial compartments in the mediastinum. Hare states that of seventy-eight cases of pyogenic mediastinal suppurations, seventeen, or 22 per cent, were of cervical origin. Pearse collected 110 cases of suppurative mediastinitis and found perforation of the cervical esophagus accountable for 58.1 per cent, suppurative cervical adenitis 11.8 per cent, retropharyngeal abscess 10 per cent, peritonsillar abscess 7.2 per cent, tracheotomy 5.5 per cent, spondylitis 2.8 per cent, thyroidectomy 2.8 per cent, and Ludwig's angina 1.8 per cent.

If the superficial types of infections such as furuncles are omitted, infections of the neck may be divided into four general groups. In this paper, only Group One will be discussed.

1. Acute suppurations secondary to infections elsewhere. Of this group, Boemer reviewed seventy-five cases and found thirty-eight from retropharyngeal abscess, eleven from deep cervical glands, nine from lower third molar, seven from superficial cervical glands, three from tonsils, two from mastoid, and five from miscellaneous sources including carcinoma and fractures.

2. Specific infections such as tuberculosis, syphilis, actinomycosis, blastomycosis, and tularemia.

3. Infected cysts and tumors, including cystic hygroma, lymphangioma, and degenerating malignant nodes.

4. Thyroiditis.

Fascial planes classified by their relation to the spread of infection may be divided into two groups: those associated with muscles, and those surrounding viscera and vessels. The muscular fascial planes are always ultimately inserted into bone, thereby sharply limiting infections in these spaces. The viscerovascular fascial spaces extend along vessels and viscera in continuity with these structures, thereby allowing infection in them to pass readily from one region to another. In the face, three muscular fascial spaces have been described: the space of the body of the mandible, the masticator space, and the parotid space, and one viscerovascular space, the pterygopharyngomaxillary or the lateral pharyngeal space.

In the neck there are also definite fascial planes of both types. After the skin, subcutaneous tissue, and platysma muscles have been reflected, the first muscular fascial plane of the neck encloses the sternocleidomastoid and trapezius muscles. This fascia is continuous with the fascial boundaries of the masticator space, and blends with the periosteum of the clavicle and sternum. Deep to this plane is found the second muscular fascial plane in which lie the sternohyoid and omohyoid muscles. Above it joins the first layer of fascia at the hyoid base to form the fused fascia, while below it splits at the sternum into two layers to form the suprasternal space. Laterally it blends with the periosteum of the posterior border of the clavicle and with the upper border of the scapula where the omohyoid is inserted. The plane then

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continues around the neck between the trapezius and the deep muscles of the neck to insert into the ligamentum nuchae. The

posteriorly surrounds the aorta. Laterally it passes with the intercostal arteries to merge with the parietal pleura. This large

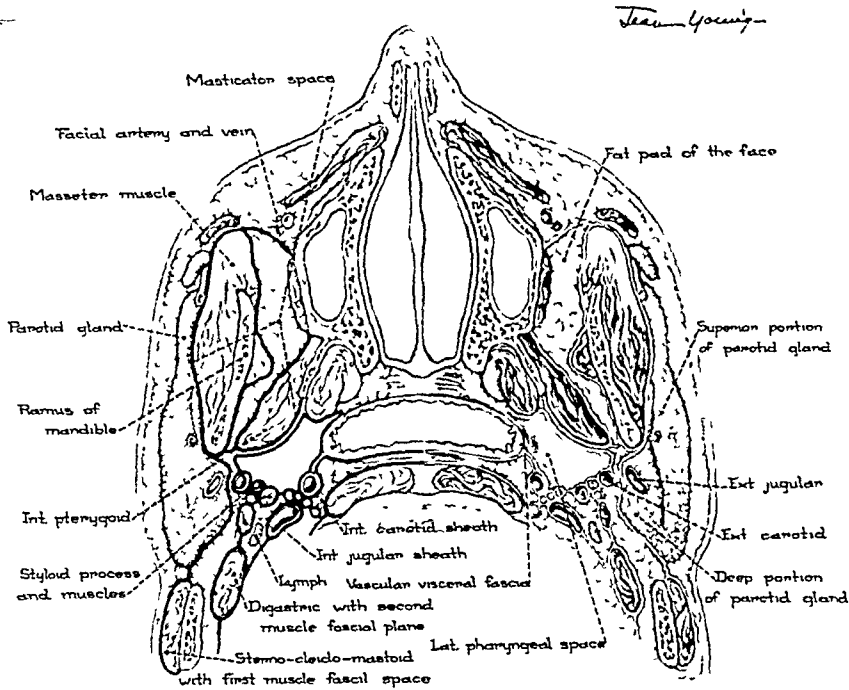


FIG. 1. Horizontal section demonstrating the different fascial planes and potential anatomic spaces. (From Coller and Yglesias, in *Surg., Gynec. & Obst.*, 60: 277, 1935.)

suprasternal space is not important as far as infections of the neck are concerned. It may be infected through stab wounds, osteomyelitis of the hyoid bone and from the lymphatics. The third muscular fascial layer is composed of the fascia enclosing the sternothyroid and thyrohyoid muscles; it continues above to the hyoid bone, laterally to fuse with the fascial sheath of the internal jugular vein, and inferiorly it is attached to the posterior border of the manubrium and first rib. This space is seldom infected and its only practical application is that the surgeon following this space laterally will meet the internal jugular vein.

The viscerovascular fascia, as its name implies, envelops the viscera of the neck and mediastinum, carotid sheath and aorta, forming a cylindric covering of the pharynx, larynx, aorta, and its branches which ascend into the neck. Within the thoracic cavity this fascial layer blends anteriorly with the pericardial sac and

space is of the greatest importance to the surgeon since it connects the mouth, throat, and pharynx and is the route along which infections commonly pass. For a better understanding of this region, it may be divided into several parts.

The fascia lying posterior to the pharynx has been called the buccopharyngeal fascia; the layer lying anterior to the trachea, the pretracheal fascia; and that portion surrounding the aorta and its branches, the vascular sheath. The lateral pharyngeal space, which may be infected from any of the three important fascial spaces of the face and from the pharynx and tonsil, can act as portal of entry to the large viscerovascular space.

The submaxillary gland is enclosed by that portion of the viscerovascular fascia that surrounds the pharynx and covers the floor of the mouth. This gland with its coverings is separated from the parotid space and subcutaneous tissue by the fused fascia of the first and second muscu-

lar fascial planes of the neck. Posteriorly the fascia covering the gland is connected to the external carotid sheath and forms

the buccopharyngeal fascia of the pharynx and the retroesophageal fascia of the esophagus. Infections arising from the

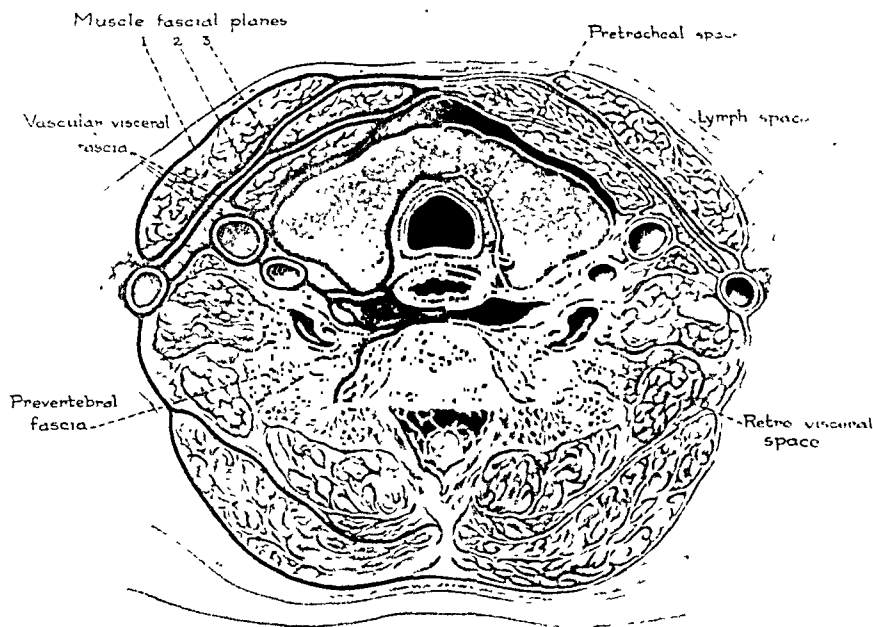


FIG. 2. Horizontal section at the neck showing dissection of the fascial planes and spaces. (From Coller and Yglesias, in *Surgery*, 1: 323, 1937.)

the floor of the lateral pharyngeal space. Infections of the submaxillary gland may perforate and infect the viscerovascular space. Diagnosis is not difficult. The infection manifests itself as a hard, tender swelling over the submaxillary triangle. The mouth is opened with difficulty and movement of the tongue is painful. Although some of these deep infections subside with conservative treatment, if the patient continues to run a septic course after twenty-four to forty-eight hours, operation is indicated. Removal of the gland has proved the best method of attack.

The pretracheal fascia is that fascia which encloses the larynx, trachea, and thyroid gland. It descends into the mediastinum surrounding the tracheobronchial lymphatic system, the arch of the aorta, and the right branch of the pulmonary artery to blend finally with the pericardial sac. Laterally in the neck, the fascia merges with the sheath of the common carotid artery. Posteriorly it continues to form

lateral wall of the pharynx, such as peritonsillar abscess or infections of the lateral pharyngeal space, may extend down to infect the entire pretracheal space. Perforations of the anterior wall of the esophagus may also reach this space. That portion of the viscerovascular fascia surrounding the carotid artery and internal jugular vein, forms the true sheath for these vessels and may be infected from the lateral pharyngeal space, but if this occurs the infection usually remains limited to the sheath.

The fascia that covers the posterior wall of the pharynx and esophagus is the retrovisceral portion of the viscerovascular system. Between this and the prevertebral fascia is a large and important space bounded laterally in the neck by the fusing of these fasciae at the point where they surround the cervical sympathetic chain. Above it extends to the basilar process of the skull and is continuous below to the diaphragm. In the thorax the lateral

boundaries are formed by the expansion of the sheath covering the descending aorta as it passes posterior to the parietal pleura

section of the retrovisceral space passing downward to expand laterally between the pleurae and the lateral expansion of the

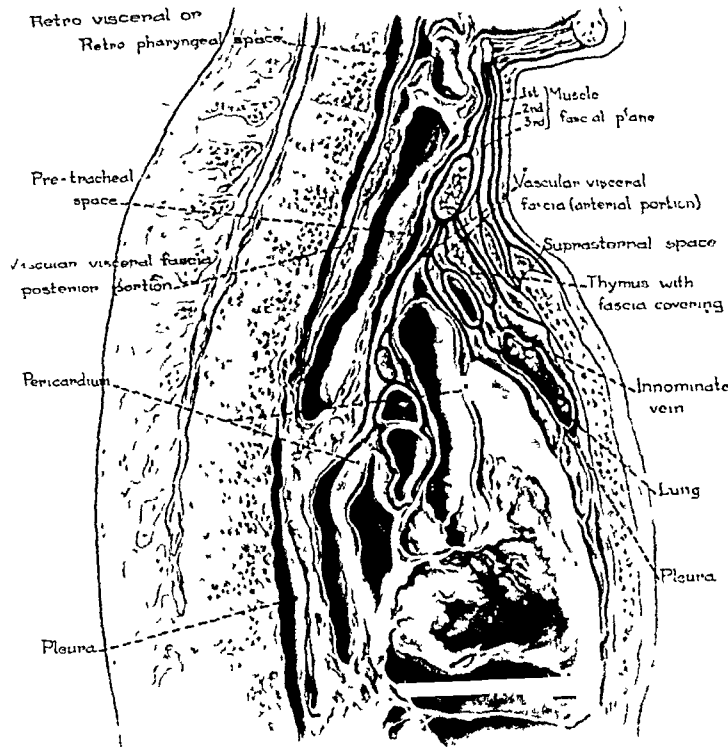


FIG. 3. Sagittal section through neck and thorax showing fascial planes and spaces. (From Coller and Yglesias, in *Surgery*, 1: 323, 1937.)

to join the posterior wall of the thorax. Below the level of the bifurcation of the trachea, the space becomes very small and may be occluded by the close approximation of the two pleurae. The clinical importance of this pathway is obvious. Its intimate relation to the vertebrae, esophagus, and lymph nodes exposes it to infection from all sides. Pyogenic and tuberculous infection arising from any bone adjacent to this area, including the basilar process of the skull, the petrous portion of the temporal bone, the cervical and dorsal vertebrae, and the posterior ends of the ribs, may spread to this space.

Infections in any of the cervical and upper dorsal vertebrae will first produce a prevertebral abscess that is limited by the prevertebral fascia, muscles, and ligaments, and will remain localized here for varying lengths of time. Eventually, however, perforation will occur with secondary in-

aortic sheath as it attaches to the thoracic wall. If the infection originates in the posterior end of the ribs, the spread of the infection will be in a reverse direction from the ribs along the space between the pleura and the lateral expansion of the sheath of the descending aorta to the retrovisceral space. For these reasons, infections in the retrovisceral space above the fourth dorsal vertebra, may best be drained by an incision in its upper portion in the neck, and infections below this point must be drained by dorsal mediastinotomy effected by posterior rib resection.

Clinically, this abscess will give rise to a variety of well known signs and symptoms, depending upon its point of origin. Dysphagia, dyspnea, dysphonia, and a bulge in the posterior pharyngeal wall are generally seen. Infants and children will have as their chief symptom dyspnea, since the posterior wall of the trachea is less

fixed and the trachea is more easily compressed than in adults. In adults dysphagia will often be the first symptom. X-ray examination will show an increase in width of the retropharyngeal space in both the frontal and lateral projections.

Drainage of infection in the retrovisceral space may be carried out through an incision made along the anterior border of the sternocleidomastoid muscle at any desired level between the hyoid bone and the sternum, depending upon the level of the infection. Cervical mediastinotomy is carried out by division of the skin, subcutaneous tissues, and platysma muscle; the first muscular fascial plane is divided along the anterior border of the sternocleidomastoid muscle; the second muscular fascial plane is divided along the lateral border of the omohyoid muscle; and the third muscular fascial plane is incised and separated from the sheath of the internal jugular vein. The lateral or lower border of the thyroid gland is lifted, and at the lower border of the thyroid is encountered the fascia passing from the thyroid to the venous portion of the viscerovascular fascia and to the thymus gland. After incising this fascia, the upper portion of the pleural-pericardial space has been opened and drainage is accomplished. This approach is best carried out on the right side, as the pleura and esophagus meet at a lower level than on the left, consequently there is less chance of inadvertently opening the pleura during the dissection. Postural drainage and intermittent suction at frequent intervals are helpful after the drainage tube is placed. In early infection of the space, incision through the posterior pharyngeal wall at point of maximum swelling will usually be adequate, but if the infection has passed down, or originated in the lower portion of the space below the fourth cervical vertebra, drainage will necessarily be carried out by external thoracotomy.

Infection of the cervical lymph glands is often encountered by the surgeon. The superficial group of glands lies under the

platysma muscle along the external jugular vein. When infected, they usually form localized subcutaneous abscesses and do not communicate with other fascial spaces of the neck. The deep group of nodes, however, lies along the great vessels of the neck in a space bounded anteriorly by the sheath of the internal jugular vein and common carotid artery, posteriorly by the fascia covering the anterior scalene muscle. The space extends upward to the mastoid and continues down to the supraclavicular fossa. Here the nodes end in the angle between the subclavian and internal jugular veins. Infection extending down this chain of nodes may pass directly to the axilla.

#### SUMMARY

A description of the fascial spaces of the neck with practical application to the routes of infection has been given. The importance of a knowledge of the fasciae and fascial spaces in anticipating the spread of infection is obvious.

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# THE SURGICAL ASPECTS OF OTITIS MEDIA, PERITONSILLAR ABSCESS AND RETROPHARYNGEAL ABSCESS

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IN the strictest sense of the word neither acute otitis media, peritonsillar abscess nor peritonsillar abscess can ordinarily be said to constitute a surgical emergency. Nevertheless each of these conditions may, through the development of certain complications or through delayed or inappropriate therapy, constitute a threat to the patient's life unless prompt surgical measures are applied. For this reason they justify consideration in this article.

## OTITIS MEDIA

It is manifestly impossible within the space here available to discuss the many and varied clinical features of this common condition. Of primary concern to the practicing physician is, first, the ability to recognize the existence of an acute otitis media; second, to apply appropriate therapy; and third, so to appraise the subsequent course of the disease as to anticipate the developments of the serious complications which may ever lie in the wake of an apparently trivial infection.

To this end it is essential that a reasonable degree of skill be acquired in methods of examination of the tympanic membrane since, more than any other single anatomic structure, it holds the key to the exact character of the pathology in the middle ear. The drum can be satisfactorily inspected only when a good and preferably artificial light is thrown into the external canal either indirectly by reflection from a head mirror or directly by means of an electric otoscope. The latter has the disadvantage of introducing a confusing element of magnification which tends to distort the characteristic appearances observable in the presence of an acute middle ear infection. While some practice is

necessary in order to master the technique of mirror reflection the physician will be well repaid in his efforts to achieve proper manipulation of the aural speculum and the direction of an unobstructed beam of light against the drum.

No satisfactory estimate of the degree of middle ear pathology as manifested by the tympanic membrane is possible without some knowledge of the normal structures for comparison. While there is no single typical appearance of the tympanic membrane, examination of a relatively small number of uninflamed drums will serve to orient the practitioner and enable him to appreciate the classical landmarks described in all textbooks. Chief among these are the pearly gray color of the membrane, the definite anterior and inferior declination of the slightly concave surface and the triangular light reflex, broken or intact, radiating from the center or umbo anteriorly toward the periphery of the anterior inferior quadrant. In addition, one must be able to recognize the handle of the malleus as it runs from the umbo superiorly and anteriorly to a small white dot, representing the so-called short process from which convex curved folds radiate posteriorly and anteriorly to demarcate the small superior portion of the drum known as Shrapnell's membrane. (Fig. 1.)

In general it can be assumed that the great majority of acute middle ear infections originate as a nasopharyngitis which by extension via the eustachian tubes come to involve the mucosa of the tympanic cavity. The condition is far commoner in children than in adults, due to the more direct course of the eustachian tube and the frequent presence of obstruct-

ing masses of lymphoid tissue in the nasopharynx which, lying in juxtaposition to the eustachian tube orifice, form an easy means of access of infection.

loses its normal luster, shows an increased hyperemia and often a surface loss of epithelium with an accumulation of irregularly scattered plaques of fibrin.

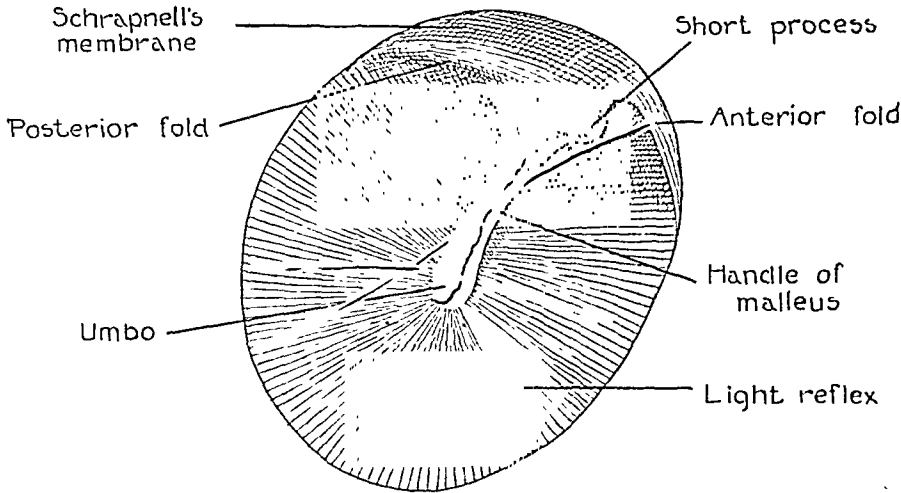


FIG. 1. Landmarks of the normal tympanic membrane (right ear). (From Richards' "Otolaryngology in General Practice," Macmillan.)

That some degree of middle ear infection is beginning to complicate an acute nasopharynx is first manifested by a sense of fulness or obstruction to normal aeration of the middle ear and by a definite hyperemia and retraction of the drum membrane. There may be no fever and only minimal discomfort. Such a situation may frequently extend no further and with appropriate measures to reduce nasal congestion and restore normal tubal ventilation, prompt resolution may occur. On the contrary, the early signs of tubal closure may be but the forerunner of further trouble. With continued congestion of the tympanic mucosa and absorption of air from the tympanic cavity there takes place an exudation of fluid which through the pressure occasioned by it produces the classical symptoms of more serious middle ear pathology, i.e., deafness, pain and the bulging or convexity of the drum. As a further result of this pressure against the drum there results a more or less complete loss of the characteristic landmarks of the drum, particularly of the light reflex, the short process and the handle of the malleus. The drum surface

Even in such an advanced state of middle ear disturbance it is still possible for normal resolution to take place and for the accumulated fluid to drain spontaneously through the eustachian tube, provided that active bacterial infection of this fluid does not complicate the situation. The entrance of this more serious factor into the picture is manifested by a febrile reaction much more pronounced in children than in adults, by more severe pain resulting from elaboration of bacterial toxins, and by a still more pathologic appearance of the drum membrane, so that it now bears scarcely any resemblance to the normal drum. Under these circumstances there can be no doubt as to the advisability of incision of the drum membrane in order to provide drainage for the purulent fluid within the middle ear cavity, which in all probability will otherwise be forced to provide its own outlet via a spontaneous perforation of the drum. Such drainage is often inadequate and to await its occurrence subjects the patient to needless and prolonged pain. Moreover, it is the opinion of otologists that awaiting spontaneous drainage is often a predispos-

ing factor in the development of such subsequent complications as mastoiditis.

Up to the point of assurance of the

crudity productive of disastrous results for the patient. Prime essentials are adequate illumination, sufficient anesthe-

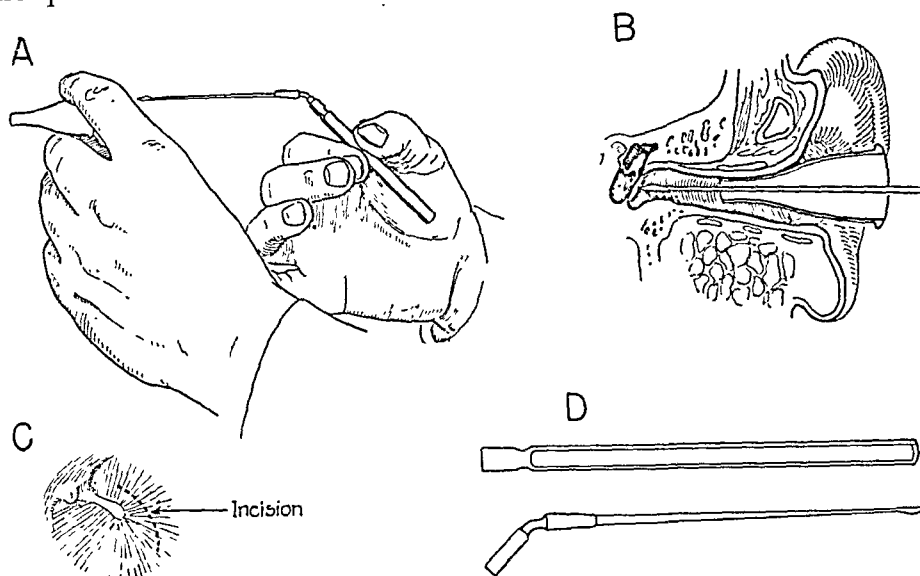


FIG. 2. Essentials in the operation of myringotomy (incision of the tympanic membrane). A, correct method of holding knife and aural speculum. The grasp of the right hand assures a delicate sense of balance and contact with the drum surface. B, relationships of the knife blade, drum membrane and aural speculum. C, approximate line of incision from above downward (left ear). D, a convenient form of knife with friction seating blade which can, when not in use, be inserted within the hollow handle and so be protected from damage. (From Richards' "Otolaryngology in General Practice," Macmillan.)

existence of a frank purulent otitis media the physician must through experience and repeated examination of the drum membrane make his own decision as to the necessity for incision of the tympanic membrane. Relief of pain by adequate sedatives and attention to the nose will frequently abort situations which might seem to require surgery. Progress toward definite accumulation of purulent fluid is often amazingly rapid and only vigilant observation will indicate the train of events. No rules can be laid down, but in general it may be said that the more rapid the progress toward severe though temporary loss of hearing, toward complete loss of all recognizable landmarks, and a definite elevation in temperature, the more certainly is surgical drainage of the tympanic cavity indicated.

Myringotomy, or incision of the drum membrane may well be considered a minor surgical procedure, but it is one which can be performed expertly or with a

sia, not only for the comfort of the patient but for the convenience of the physician, and a proper armamentarium of which the most important constituent is a sharp knife. Of this latter there are many variations; the one shown in Figure 2 has many advantageous features.

Equally important is the proper placing of the incision. This should be of adequate length and not in the nature of what is still erroneously called a paracentesis. Such placement is rendered the more difficult because of the often complete absence of all landmarks, and particularly of the otherwise clearly evident line of angulation between the posterior canal wall and the posterior margin of the drum. Inept incision of the former is not only futile in securing adequate middle ear drainage but productive of possibly undesirable complications outside the middle ear. Ideally the incision, carried from above downward, should run about halfway between the line of the handle of the malleus and the



posterior margin of the drum, starting near the superior drum margin and extending in a curve as nearly as possible to the floor of the canal. Further difficulty will at first be encountered in estimating the depth of penetration of the knife point through the drum membrane which, often greatly thickened by the inflammatory process, will offer all varieties of resistance to incision. In the presence of marked bulging and fluid and even air bubbles under considerable pressure, the drum may be so stretched that even the lightest touch will penetrate, whereas it may be so porky and edematous as to require a distinct effort to pierce it. Essential in either case is the avoidance of contact with the inner tympanic wall which harbors structures whose injury is always to be avoided. In general it may be said that penetration of the knife point not more than  $\frac{1}{8}$  inch beyond the inner drum surface will be quite adequate and will avoid all danger. With descent of the blade the point must be carried slightly inward to conform to the normal inward declination of the drum.

Some form of anesthesia will greatly facilitate the execution of any myringotomy. For children up to the age of 3 years primary induction with ether will prove eminently satisfactory; even in the face of an upper respiratory infection it carries only a minimum risk of pulmonary infection. Its short duration still allows ample time for the incision if necessary, of both drums, recovery is rapid and the after effects are seldom, if ever, of any significance. As a substitute many otologists prefer the use of ethyl chloride sprayed on a small piece of gauze with the admixture of an ample supply of air, though anesthetists all claim an added risk as compared with ether. For older children and adults gas oxygen will prove in general satisfactory, though a tendency to stridor, cyanosis, and head movement are unpleasant features from the standpoint of the surgeon. Both ether and ethyl chloride can be administered by the

operator, but gas necessitates an assistant and the transportation of cumbersome apparatus.

For those who, with adults, prefer a local anesthesia, there is available the following mixture:

Cocaine hydrochloride	
Menthol	
Carbolic acid.....	aa 5 ss
Rectified spirits of wine	
Oil of cloves.....	aa 5 ss

This medication is to be dropped in the aural canal and left in contact with the drum for twenty minutes, or a cotton pledget soaked in the solution may be placed in contact with it. While in some ways not so satisfactory, this anesthesia in the hands of those accustomed to using it has proved quite adequate.

Proper incision of the tympanic membrane may be followed by one of several results. In the presence of a thin tense drum, there will often be heard a crackling, snapping sound, with an immediate evident release of turbid fluid which, slightly blood tinged, soon fills the auditory canal. From a prognostic standpoint such a result can be viewed with justifiable hope that a rapid convalescence will ensue with prompt relief of pain and an absence of complications, the possible development of which makes even a simple otitis media an always potentially dangerous condition. In those instances in which incision yields the sensation of cutting through thick edematous tissue, the immediate flow of purulent fluid is quickly obscured by profuse bleeding without the sensation of the release of any intratympanic pressure.

In either case there arises the problem of immediate after-care and proper methods for dealing with the subsequent discharge. A variety of methods have found favor according to the individual preference of the physician. So-called dry treatment involves the insertion into the aural canal of some type of gauze or cotton wick, reaching, if possible, down to the drum surface and designed to act as a capillary drain to promote the best possible drain-

age. Such wicks must be frequently changed as soon as saturated and for this reason make often impossible demands on the physician's time, as patients or parents are usually incapable of caring for this matter personally.

This situation has led to the frequent adoption of the method of irrigating or syringing the aural canal with some bland solution such as boric acid or normal saline. This is best introduced by means of a container elevated above the patient's head, with the fluid flowing through the tubing and out through a glass medicine dropper tip inserted just within the external auditory meatus.

In the opinion of many competent observers no marked superiority lies in either form of after-care, provided that adequate drainage is maintained from the middle ear. Of far greater importance is the accurate appraisal of the subsequent course of the disease, since on this depends the application of the proper surgical therapy in the event that the infection extends beyond the confines of the middle ear to involve the adjacent pneumatic structures known as the mastoid.

#### ACUTE MASTOIDITIS

As indicating various degrees of progress toward such a complication, certain features of the clinical course must be recognized and understood. In many instances incision of the drum membrane may in a few days be followed by prompt subsidence of all symptoms. Fever and pain will promptly abate, and the discharge, at first profuse, will soon diminish and disappear. Normal hearing will return and clinically a cure is established—the outcome in thousands of cases of acute otitis media. In other instances resolution will take place more gradually, fever will persist for ten days to two weeks, returning to normal with irregular picket-fence swings, pain may not be immediately relieved and poor hearing may persist. In such instances there must always exist the suspicion that the infection has not

been confined to the middle ear but may have invaded the pneumatic extensions of the middle ear cavity which in their fine arborizations and subdivisions occupy the mastoid process. The direct contiguity of the lining of the mastoid cells with the mucosa of the middle ear makes such an extension always a clinical possibility. The additional finding of tenderness on pressure over the mastoid and edema or even erythema of the overlying skin and periosteum still further strengthen the suspicion of the existence of acute mastoiditis.

Such early signs of mastoid involvement, are however, no guaranties that surgical intervention will be required. With continued efficient drainage of the middle ear and the development on the part of the patient of adequate bodily defenses against the infection, recovery will frequently take place with no untoward sequelae. The assurance, in the face of persisting fever and discharge, that such a favorable outcome is at least possible, if not probable, is to be sought in repeated careful observations of the tympanic membrane. With slow but steady improvement, changes will be noted in the appearance of the drum which presage recovery. Whereas at the height of the infection all normal landmarks are no longer recognizable and the drum surface is highly distorted, there will occur a gradual reappearance of those features which make up the normal membrane. The surface will begin to flatten and lose its irregularity. The periphery will appear more clean cut and more sharply demarcated from the adjacent canal walls, suggestions of such landmarks as the malleus handle and its short process will be evident, and particularly the site of the perforation, heretofore unrecognizable, will be visible. With continued favorable progress, the edges of the perforation will become more distinct, a valuable indication that the entire mucosa of the middle ear is undergoing the thinning process which is such a pronounced feature of resolution of the infection. Discharge may persist in the face of all these signs, but

with coincident fall in temperature, improvement in hearing and further well being of the patient it is usually safe to delay any surgical attack on the mastoid for at least a reasonable period. How long such a period will be, cannot be specifically stated. At the outset of this type of middle ear infection, the clinical picture may be such as to tempt the physician to conclude that immediate mastoidectomy is indicated. Fever, mastoid tenderness, pain and suggestions of toxemia in the patient's general appearance all may justify the feeling. Nevertheless, in the opinion of most competent otologists a delay of at least a week's time following drum incision, if supplemented with supportive treatment, is frequently not only justifiable but advisable.

Unquestionably in occasional instances, mastoiditis may be considered a surgical emergency, but as a rule there is no necessity for haste and temperate delay during a careful observation of the patient will prove the best policy. Even if resolution as above described does not take place, no essential disadvantage occurs from such delay. In the course of ten days to two weeks it will then be apparent that the desired improvement in the drum is not taking place. There is no sign of returning landmarks, the drum still looks thick and peripherally constricted, the site of perforation is not evident or else is seen to present a nipple of protruding tympanic mucosa, and the discharge is as thick and purulent as ever. Nevertheless, the patient may feel better and suffer no pain; there may be no trace of mastoid tenderness or edema; and fever may be of so low grade a type as to attract but little attention. It is precisely in this situation that mastoid surgery is often clearly indicated. Further hopeful delay will be provocative only of further middle ear drainage with possible permanent hearing defects and eventual implantation of a chronic bone infection most difficult of eradication.

Believing the absence of acute symptoms to signify recovery, the patient and his

family are the more surprised to be told that a mastoid operation is necessary. It is the application of just such properly timed surgery that has been so successful in reducing the number of cases of chronic otitis media and in preserving the hearing of thousands of children which would otherwise have been partially or totally lost.

From time to time particularly in the case of infants and young children, less frequently in adults, there will be observed the typical post-aural swelling, erythema, tenderness and sometimes fluctuation which combine to form the textbook picture of acute suppurative mastoiditis. These signs result from a perforation of the mastoid cortex with a resultant escape of pus under the periosteum to produce an inflammatory reaction in the overlying soft tissue. While by no means constituting a true emergency, the indications for surgery are quite obvious. Simple incision and drainage of superficial pus will usually not suffice to cure the associated otitis media and thorough eradication of the underlying and more deeply infected mastoid cells will usually be required. Care must be taken that such post-aural edema and tenderness be not mistaken for a somewhat similar finding due to an infection, diffuse or circumscribed, of the external auditory canal. A careful examination of the canal and drum membrane will usually serve to avoid this confusion.

From the above it will be apparent that the decision as to the advisability and urgency of any drainage of the mastoid process depends first of all on an appraisal of the patient's general condition and the progress with which he succeeds or fails in overcoming the infection, and second, on a thorough understanding of the significance of the various phases exhibited by the drum membrane. Where definite, albeit slow, improvement is clearly evident, it is often good judgment to delay any surgical intervention. When classical signs indicate that the patient, both locally

and systemically, is losing ground, consideration of more radical measures is necessary. No definite time limit can be applied to a given situation and experience and surgical judgment must be the basis for decision.

#### SINUS THROMBOSIS

During the course of an acute otitis media either before the damage of a complicating mastoiditis or after it, certain symptoms may be present to indicate the development of a complication which may necessitate either more prompt initial surgery or secondary and more radical measures. The basis for this fact lies in the close proximity to the mastoid process of the lateral sinus, the large venous channel which, passing downward and anteriorly from the torcula Herophili, becomes the internal jugular vein. As it traverses the mastoid it may lie in close relationship with infected mastoid cells which, either by direct continuity or through a thrombosis forming in small venous channels in the bone, provoke an inflammatory reaction in this venous channel. This reaction may at first consist of a simple phlebitis of the venous wall which will subside with prompt removal of the overlying infected mastoid cells or interception of the small infected venules leading into the vein. If neglected or unrecognized the process may go on to thrombus formation, either mural or occlusive, with secondary systemic propagation of infection into the blood stream (septicemia or bacteremia) or to isolated parts of the body with metastatic abscess formation (pyemia). It is obvious that such phlebitis or sinus thrombosis demands prompt recognition and usually surgical therapy in order to forestall such potentially serious complications. Details of the many surgical problems arising in connection with sinus surgery are beyond the scope of this paper.

While there is no classical clinical picture of such a situation, lesions of the lateral sinus are commonly manifested by a

higher and more irregular type of fever than is consistent with simple mastoiditis, frequently by recurrent chills and, if well established, often by the presence on culture of active organisms in the blood stream. Since such a systemic complication is most often due to the *Streptococcus hemolyticus*, there is almost certain to be present a slowly progressive anemia, the recognition of which is important both diagnostically and therapeutically, small and frequent transfusions being an important part of the treatment.

It is essential in the face of the above symptoms not to lose sight of the possibility of other conditions which in the presence of an acute otitis media may simulate sinus thrombosis. Such are acute cervical adenitis, pyelitis, acute nephritis, early erysipelas and a central pneumonia, undetectable by ordinary physical examination. For this reason, hasty surgical attack is to be withheld until the presence of a sinus complication is as assured as all diagnostic means can achieve, lest inappropriate operative measures serve only to complicate the situation. To this extent the condition of sinus thrombosis is not an emergency, and the necessary time to make use of customary diagnostic procedures such as a blood culture, chest x-ray, and complete urine examination will be more than justified and will in no way jeopardize the patient's chances of recovery.

#### MENINGITIS

More nearly constituting a surgical emergency in otitis media is the complication of meningitis. Since the middle ear, mastoid antrum, and certain mastoid cells lie in close proximity to the dura of the middle fossa and since the intervening thin plates of bone may be readily destroyed by infection, meningeal irritation or actual subarachnoid infection may follow otitic suppuration. Even in the absence of actual bone destruction meningeal infections may arise from the propagation of aural infection by way of small vascular pathways leading to the

meninges. Such a complication not infrequently makes its appearance at the very outset of an acute middle ear inflammation almost before the clinical picture of the latter is definitely established. At other times meningitis may be associated with a definite mastoiditis either before this has been cared for surgically or as a postoperative complication.

Such meningeal infection has in recent years been the subject of most intensive study by otologists who have sought in every possible way to discover early diagnostic signs which would point the way to the development of otitic meningitis before it becomes full-blown. Study of the chemistry of the spinal fluid and of the blood is playing an important part in this endeavor to appreciate the significance of apparently minor disturbances in the patient's condition are being found to be significant warnings. Headache, photophobia, vomiting, or undue irritability during the course of an acute otitis media or mastoiditis would at once arouse the suspicion of the possibility of meningeal complications and warrant the application of all recognized methods of diagnosis. Given the presumable existence of a definite meningeal infection, prompt surgical exposure of the dura in the region of the middle ear and mastoid cells is the accepted mode of attack, supplemented by all other possible means of combating this serious complication.

In this connection, mention should be made of the present enthusiasm, particularly in otitic meningitis, for the use of sulfanilamide. Until the advent of this drug, this condition, in spite of every known form of therapy, carried a mortality rate of between 90 and 95 per cent. To date the prompt institution of surgical drainage in combination with sulfanilamide therapy has served to reduce the figure to an astounding extent and the literature is replete with reports of recovery in cases which would formerly have been considered utterly hopeless. Of use particularly in meningeal infections, sulf-

anilamide has also been employed extensively in simple acute otitis media in the hope of avoiding mastoiditis and in mastoiditis with a view to localizing the process and preventing the development of such complications as have been above described. At present there is still some controversy as to the value of the drug in this field, considering the possibility of its masking valuable signs of the extent of a mastoid infection and the possible disadvantage and even danger in its use. Further clinical experience will be necessary before final conclusions can be drawn.

The above consideration of otitis media from the standpoint of the application, early or delayed, or appropriate surgical therapy has necessarily omitted much that is pertinent to the discussion or that would seem essential from the viewpoint of the otologist. For the practicing physician who will from time to time encounter the diseases it is chiefly essential, (1) that he be able by a competent examination to make the diagnosis of an acute otitis media; (2) that he comprehend the recognized indications for incision of the drum and the technique of its execution; (3) that he be able to appraise the clinical course and at least sense that it is or is not proceeding satisfactorily; and, (4) that he be alert to secure competent help in the event that his observations indicate impending and possibly serious complications.

#### PERITONSILLAR ABSCESS

A peritonsillar abscess or "quinsy sore throat" is frequently the occasion for surgical drainage, first, to relieve the severe pain which is so pronounced a feature and secondly, to forestall the development of respiratory obstruction which is at times a complicating factor. Where the latter situation is clearly evident, drainage becomes in a sense urgent and hence this might properly be said to constitute an emergency. In by far the greatest number of instances, however, classical signs of such an abscess

are plainly evident long before respiratory obstruction is a serious consideration and the institution of drainage will usually prevent its development.

undergoing apparent resolution, appears from the patient's point of view to recur but now only on one side. The pain attending this return of the sore throat is, how-

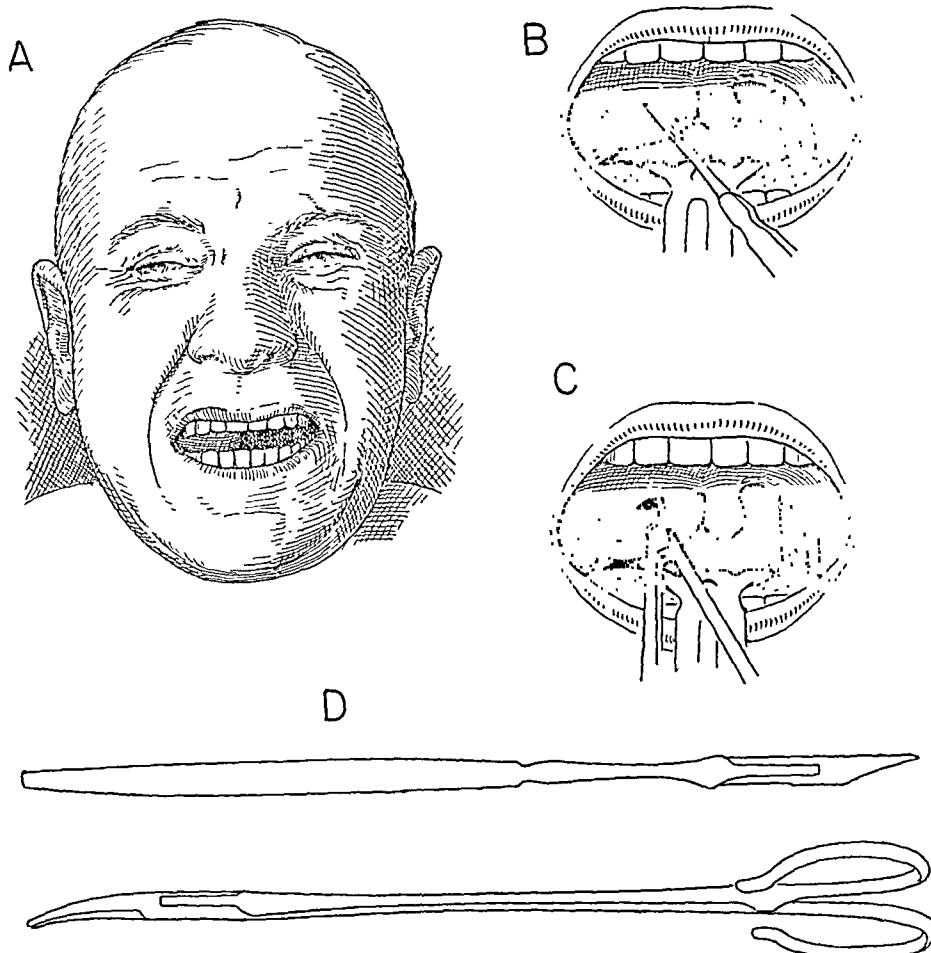


FIG. 3. Peritonsillar abscess (quinsy sore throat). A, characteristic facies of a patient with peritonsillar abscess, exhibiting the extreme pain and trismus incident to attempts to open the mouth. With the exception of perialveolar abscess, few other acute laryngological infections produce this appearance. B, incision of the abscess. After cocaineization, the sharp knife point is centered at the area of maximum tenderness, induration and blanching to a depth of approximately  $\frac{1}{2}$  to  $\frac{3}{4}$  inch. This will commonly be followed by a trickle of pus. C, insertion of the hemostat and spreading of the edges of the incision. D, the knife and hemostat suitable for incision and drainage of a peritonsillar abscess. (From Richards' "Otolaryngology in General Practice," Macmillan.)

A peritonsillar abscess in the true sense of the word is an accumulation of pus in the potential tissue space which is bounded superiorly by the superior pole of the tonsil, anteriorly by the soft palate and anterior tonsillar pillar and posteriorly by the superior constrictor muscle of the pharynx. The development of such an abscess is commonly preceded by an acute tonsillitis, usually bilateral, which, after

ever, much greater than with the original tonsillitis. The condition is almost universally confined to patients over 12 years of age. The condition said to be a "peritonsillar abscess" in a child will usually be found on closer examination to represent infections or collections of pus either back of the tonsillar bed just outside the pharyngeal fascia or in the lateral retropharyngeal space where the resultant

swelling tends to push the tonsil forward. In neither instance will pus be found in the supratonsillar space and the classical findings described below will not be evident.

Of rapid development and of almost pathognomonic significance in peritonsillar abscess is the sign of trismus, provoking in a few hours the greatest difficulty for the patient in opening his mouth. Frequently the dental margins cannot be separated more than 1 or 2 cm., a situation resulting from an infiltration of the pterygoid muscles with attendant spasm and fixation. Tetanus and perialveolar abscess are the only other two conditions which provoke like difficulty. Fever is seldom a prominent symptom, temperature ranging usually below 100 degrees. In contradistinction to neck infections which are localized externally to the pharyngeal fascia, there is usually no external swelling of the neck, and often practically no tenderness.

The patient presents a characteristic appearance. (Fig. 3.) Swallowing is so painful that saliva is allowed to drool from the lips and all food and liquids are refused. The voice, as a result of the palatal edema, has a distinct nasal quality but laryngeal involvement with hoarseness is rare.

Examination of the throat is rendered extremely difficult because of the inability of the patient to open his mouth although gentle insinuation of a thin bladed tongue depressor will usually permit a fairly satisfactory view of the site of the abscess. The entire region of the involved tonsil is the site of a marked edema of the soft tissues. The demarcation between the tonsil and the anterior pillar is obliterated and the soft palate up to or even beyond the midline is swollen and fiery red in color. The extension of this edema to the uvula often results in a characteristic displacement of this swollen structure to the opposite side. If space between the teeth permits, palpation with the index finger or a cotton tipped probe will, in a well advanced abscess, reveal a certain point of maximum tension and blanching on pressure, the location of

which is important in selecting the site for drainage.

While the development of such a peritonsillar abscess is rapid, there is nevertheless a developmental period when, in spite of obvious signs pointing to the existence of such an abscess, attempts at drainage are fraught with risk of failure. During the period before the assurance of definite localization it is usually wise to delay incision and make the patient comfortable by the administration of adequate sedatives and by utilization of such local measures as hot saline or glucose irrigations and external heat. Within twenty-four to forty-eight hours such treatment will usually result in the appearance of signs of localization, chief of which is the recognition on palpation of a point of maximum tenderness, resistance or even vague fluctuation. This will commonly be located in the soft palate about midway between the dental line and the uvula and about a centimeter above the normal location of the top of the tonsil.

Such delay, perhaps to the temporary disappointment of the patient, will spare him the agonizing discomfort of abortive attempts to drain an abscess not yet present. The procedure is not only provocative of immediate severe pain, but necessitates a secondary incision at a later and more appropriate date, oftentimes by a second physician whose immediate success will contrast most unfavorably in the patient's mind with the failure of his predecessor.

*Incision and Drainage.* Any form of general anesthesia is to be avoided. The dangers of complete narcosis in the presence of marked trismus are clearly evident, and the policy of some operators of excellent reputation of removing the tonsils at the same time would seem to carry an unnecessary risk. It is true that ideal local anesthesia is difficult to secure, owing to the intense edema of the palatal tissues, but the application of a swab soaked in 10 per cent cocaine to the region of the proposed incision will prove reasonably satisfactory for all but the final stretching

of the wound edges. Incision is best begun by the insertion at the point of maximum tension, fulness, bulging or blanching of the blade of a long handled sharp knife. (Fig. 3.) The knife point is carefully advanced toward the presumed center of the abscess for a distance of about 1 to 1.5 cm. and then withdrawn. With the use of cocaine as above described this initial incision will prove surprisingly painless. If the abscess cavity has been entered the withdrawal of the knife blade will be promptly followed by a thin trickle of pus from the point of the incision. If this favorable sign does not appear the abscess may not as yet have localized, premature incision may have been undertaken and further attempts to enlarge the incision should be avoided till a later date. It is possible that the abscess, though present, has not been reached. A slightly deeper penetration at the same point may yield pus, but promiscuous stabbing here and there will serve only to hurt the patient and possibly to disseminate infection into uninfected tissue planes with disastrous results. Given a properly timed incision and definite clinical signs of an abscess, preliminary incision will usually "strike oil." This result having been achieved, it remains to enlarge this drainage tract by inserting into it the closed blades of a long handled hemostat. With the blades inserted within the abscess cavity, a single opening will serve to establish an adequate wound of exit which will seldom require further enlargement. (Fig. 3.) This second step in drainage is admittedly painful and no form of local anesthesia will entirely eliminate this momentary discomfort, but it is so regularly followed by marked relief in an astoundingly short time as to more than justify this method. Within a half hour the patient will frequently experience marked relief and under continued administration of hot throat irrigations the entire inflammatory process rapidly subsides. It is seldom necessary to undertake any secondary incision, though there is occasionally a tendency for the wound edges to seal

together and to require gentle separation. Often at the end of a week it is difficult to observe any sign of the previously severe inflammatory reaction.

Subsequent attacks of peritonsillar abscess are best avoided by complete tonsillectomy undertaken during an interval of complete freedom from local inflammation. Such a tonsillectomy will often prove more than ordinarily difficult because of adhesions resulting from the previous peritonsillar infection and great care must be taken in the dissection to avoid tearing the peritonsillar tissues and particularly the leaving of any tonsillar remnant at the superior pole. Such a remnant may later form an ideal spot for recurrent inflammation which may closely simulate a peritonsillar abscess.

Untreated or undrained, a peritonsillar abscess may eventually rupture spontaneously without untoward results. To await this outcome in preference to surgical incision and drainage is to subject the patient to unnecessarily prolonged discomfort as well as to risk aspiration of the contents of the abscess with possible subsequent inhalatory pneumonia.

#### RETROPHARYNGEAL ABSCESS

It has been said by prominent pediatricians that a retropharyngeal abscess is more often inaccurately diagnosed than any other condition in infancy. This situation arises primarily from the fact that such an abscess may, because of its protean manifestations, so simulate a number of totally unrelated diseases as to create frequent difficulties in diagnosis.

Pathologically, retropharyngeal abscess develops as an enlargement of one of the several pharyngeal lymph nodes which lie beneath the mucosa of the pharynx anterior to the cervical spine. Such glands are usually located to the left or right of the midline at varying levels, so high as to be hidden behind the soft palate or so low as to be retrolaryngeal or even retroesophageal. With progression of pyogenic infection which reaches these glands from some



primary focus in the nasopharynx, the glands begin to undergo liquefaction and to break down into a frank abscess.

As such an abscess enlarges, it may, depending on its location, cause a wide variety of symptoms. A relatively high abscess will produce obstruction to nasal breathing and may readily be mistaken for an enlarged adenoid. If occupying the region of the nasopharynx, such a swelling of the posterior pharyngeal wall will provoke difficulty in swallowing more often due to mechanical interference than to pain. Stiffness of the neck, so frequently associated with retropharyngeal abscess may be confused with such orthopedic conditions as cervical spine disease or torticollis, or may be of such severity as to give rise to the suspicion of the presence of meningitis.

The picture of some degree of surgical urgency may be created by an abscess which, lying directly posterior to the larynx, either presses against the latter directly or so overhangs it as partially to block the glottic entrance. The resultant dyspnea may not only be severe, but may be such as to suggest its source to be in the larynx itself and thus to provoke measures for its relief which fail to take into consideration the true nature of the difficulty. Thus tracheotomy for such a form of laryngeal obstruction is by no means as suitable as drainage of the retropharyngeal abscess which is the basic cause for the laryngeal symptoms.

Less obviously related symptoms such as sore throat, cough, unexplained fever and even convulsions in infants and younger children may all be due to a retropharyngeal abscess, the existence of which may not be suspected either from the history or the conventional examination of the throat.

The best method of avoiding this diagnostic dilemma is the constant retention in the mind of the examining physician that a retropharyngeal abscess in this age group from birth to 3 years may be responsible for any of the aforementioned

symptoms. Other causes will often enough be present, but if an abscess is ruled out by inspection, palpation and x-ray, few diagnostic errors will be made.

Proper examination of a retropharyngeal abscess is not the simple matter that one might at first consider it. The forceful depression of a prominent tongue will not only frequently fail to reveal an abscess that lies either above or below the direct line of vision, but has been known on more than one occasion to provoke either temporary cessation of respiration or even to initiate a rapidly fatal apnea. By the same token the forceful opening of the mouth with a mouth gag is strongly contraindicated since it is capable of leading to equally disastrous results. Far safer and more informative is the introduction into the mouth of the left index finger with the physician standing at the patient's head and facing the patient's feet. In this manner the finger may readily be swept over the entire posterior pharyngeal wall from the level of the soft palate to a point well below the larynx. The involuntary gag reflex will adequately protect the finger from injury in older children. By this means the characteristic unilateral protrusion and the tense, smooth and elastic wall of the abscess will be readily recognized after one or two encounters with this condition. Such palpation will often prove far more informative than inspection, which, if the abscess is beyond the line of vision, will frequently be entirely negative.

Supplementing physical examination and available even before any local inspection is a lateral x-ray of the cervical spine, which will usually show the presence of a retropharyngeal abscess as a marked forward deviation of the soft tissue line of the pharynx or upper esophagus. Whenever possible, such Roentgen ray examination should never be omitted when retropharyngeal examination is under consideration.

Incision and drainage of a retropharyngeal abscess should almost always be undertaken without any anesthesia. Local anesthesia in infants and younger children

is fraught with definite danger of toxic absorption, and general anesthesia is contraindicated because of the risk of possible

with the patient in an upright position, by palpating the anterior surface of the abscess with the left index finger and then blindly

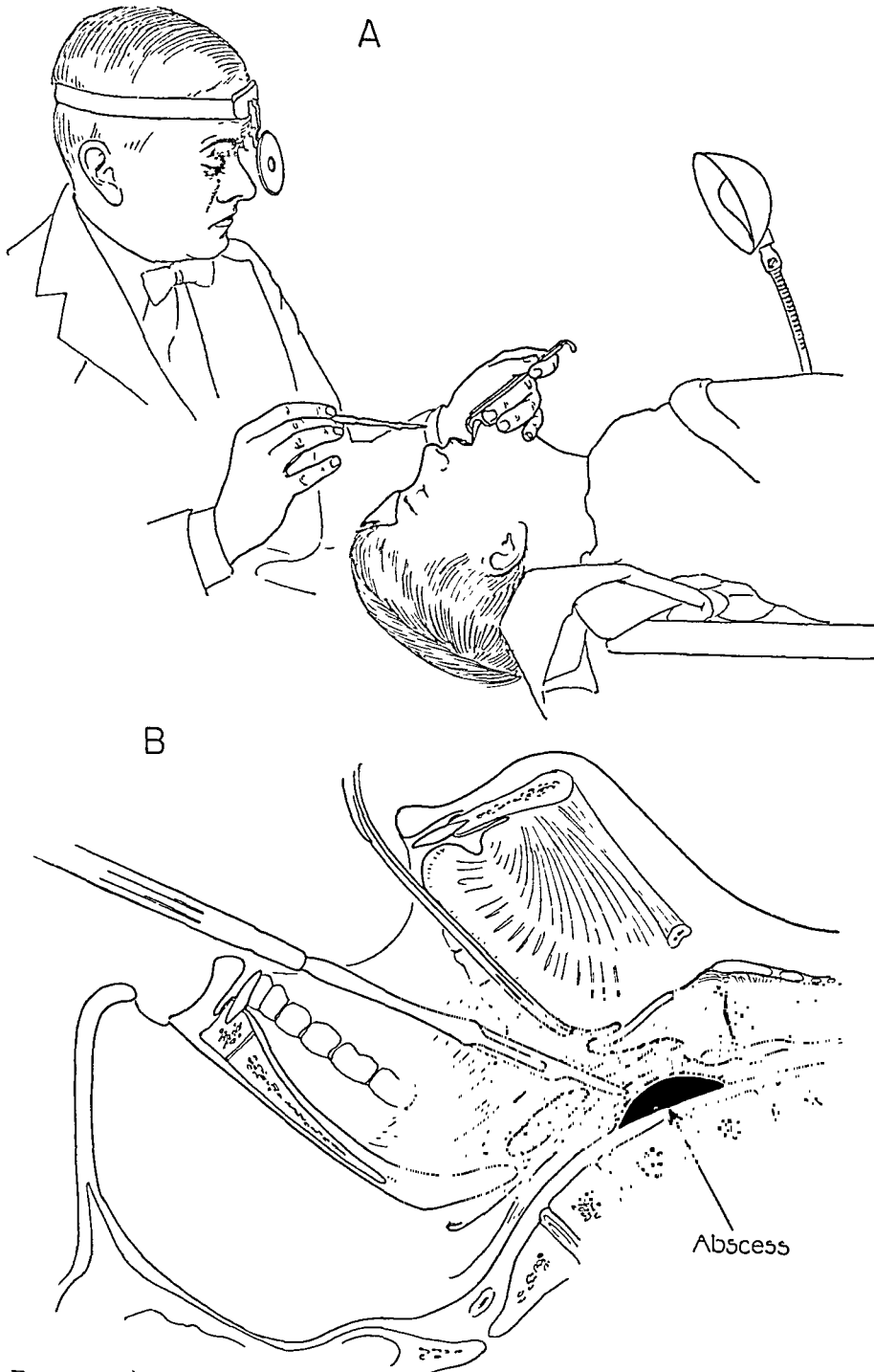


FIG. 4. Incision and drainage of retropharyngeal abscess. A, positional relationship of operator and patient. B, detail of incision of abscess. (From Richards' "Otolaryngology in General Practice," Macmillan.)

respiratory obstruction in the presence of any retropharyngeal swelling. It was formerly a common custom to incise the abscess,

passing the point of a long handled knife along this finger and penetrating the wall of the abscess. The patient's position was

then immediately reversed and the head allowed to hang down to permit the evacuated pus to run out of the mouth.

This procedure obviously lacking all the advantages of direct visionary control, carried the risk of inaccurate placement of the incision with possible damage to adjacent structures in the pharynx. With many operators it has been supplanted by the method illustrated in Figure 4. The patient lies on his back, properly restrained by wrapping in a blanket, and the physician is seated at the head, viewing the throat by light reflected to the pharyngeal wall from a head mirror. A simple angulated tongue depressor serves to *elevate* the tongue, thus exposing and illuminating the entire posterior pharyngeal region and site of the abscess. A suitable knife blade is then carried directly to the point of maximum fluctuation in full view of the operator. As in the case of peritonsillar abscess the proper placement of the incision will be at once manifest by the appearance of a trickle of pus following withdrawal of the knife blade. A small suction tube is then employed slowly to evacuate the abscess cavity and at the same time to prevent the possible access of pus to the lower airway. As a final assurance of good drainage, the edges of the incision are widely separated by inserting between them the closed blades of a hemostat and by opening them in situ. The usually small amount of bleeding incident to the incision will cause no concern, but if more than ordinarily profuse, may be controlled by temporary insertion of a gauze tampon within the abscess cavity. A sudden profuse hemorrhage would on the rarest occasion give all too tardy warning that not an abscess but an aneurysm had been incised.

Convalescence is usually rapid and uneventful. No special after-care is required and necessity for any secondary incision is quite rare. The associated unilateral cervical adenitis so often seen in conjunction with retropharyngeal abscess will usually

subside but may at times require independent and external incision.

The single complication which must ever be borne in mind is secondary hemorrhage. This originates not in the abscess cavity per se, but rather as a result of deeper extension of the original infection in the retropharyngeal tissues to the point where there takes place an erosion of the internal carotid artery. As a measure of self protection, the vessel then builds up a pseudoaneurysm and a laminated clot which periodically weakens and permits a sudden flow of blood from the pharyngeal wound. Such a sudden hemorrhage may recur at intervals on several occasions. Its first appearance, however, is a clear indication to the physician of impending catastrophe and no time should be lost in ligating the carotid artery on the appropriate side. It is preferable to tie the common carotid, since this procedure still permits some arterial blood to reach the brain by retrograde flow of collateral circulation from the opposite side via the external carotid. Any subsequent bleeding, indicating that common carotid ligature is not adequate, should be immediately dealt with by ligature of the internal carotid as the only assured means of forestalling a subsequent and possibly fatal hemorrhage. Such ligation for this unusual complication may well be classed as a surgical emergency.

Tracheotomy, properly speaking, should seldom if ever be required in the treatment of retropharyngeal abscess even in the face of threatened respiratory obstruction, since prompt evacuation of the abscess will almost always be quite adequate to restore a patent airway. It is conceivable that on rare occasions impending asphyxia may so threaten the patient's life that an emergency tracheotomy will be necessitated by the lack of time available for investigation and drainage of the abscess itself. Under these circumstances a retropharyngeal abscess would occupy a prominent position in any list of surgical emergencies.

# TRACHEOTOMY

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TRACHEOTOMY, one of the oldest operations in surgery is today done badly more often than any other surgical procedure. The faults are closely related to surgical literature. One of the greatest literary faults is the perpetuation of the traditional division of the procedures into high tracheotomy and low tracheotomy with reference solely to whether it is done above or below the isthmus of the thyroid gland. This is a relic of the time when all conscientious surgeons regarded the thyroid gland as a *noli me tangere*. Asepsis and other improvements in technique brought the thyroid gland into the field of everyday surgery but the old tradition was handed down from textbook to textbook without recognition of the utter absurdity of the surgeon being influenced by the location of the inconsequential isthmus.<sup>1,2</sup>

The worst feature of this absurd classification was the faulty teaching that went with it in all the textbooks. As a consequence the medical graduate had in mind that the high operation was easy, the low operation difficult. The result of these false conceptions was that the occasional operator in an emergency did a high and hasty operation which usually meant a technically bad operation, even though the life of the patient was saved by it.<sup>2</sup> The thyroid and cricoid cartilages were often cut and a series of disastrous complications usually followed. So great a surgeon as Billroth made a statement to the effect that tracheotomy in some cases is easy, in others it may be one of the most difficult procedures in surgery. The only conceivable reason for such a misconception is that he was thinking of a low operation done in a

deep wound through a short skin incision. With a long median incision giving access to the whole median front of the neck no experienced surgeon has any difficulty in finding and incising the trachea through the second and third rings.

The faults of the literature are not yet wholly eradicated.

## INDICATIONS

The chief indication is to prevent asphyxia. This indication arises most frequently because of obstruction of the airway somewhere between the pharynx and the main bronchi. As a clinical fact the obstruction usually occurs in the region of the larynx, but we see also many cases of endotracheal and peritracheal disease in which asphyxia is certain unless tracheotomy is done and proper cannulae reaching below the obstruction are fitted. Air can be efficiently piped down to either or both of the main bronchi.

*Obstructive laryngeal dyspnea*, as a rule, is an indication for tracheotomy. Though it may be said the urgency of the indication is in direct proportion to the degree of dyspnea, yet if this indication is present at all tracheotomy had better be done at once. Postponing it when signs of this form of obstruction are present is justified only when there is good reason to expect the obstruction will soon subside. Even under such circumstances postponement is dangerous unless the patient is in charge of a trained nurse experienced in tracheotomic cases and a competent surgeon is within a few minutes distance. The cardinal signs of obstructive laryngeal dyspnea are, indrawing at (a) the suprasternal notch, (b) around the median end of the clavicles,

(c) in the intercostal spaces, and (d) at the epigastrium.<sup>13</sup> The most marked and most important of these is indrawing at the

scopie aspirations have obviated the necessity for tracheotomy for aspiration. In the early days of bronchoscopy tracheotomy

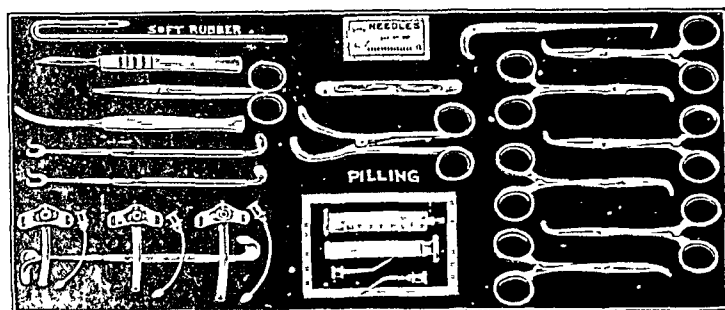


FIG. 1. Instruments that should be available for tracheotomy. Make-shifts will do, but good surgery requires adequate equipment.<sup>6</sup>

suprasternal notch, often called the guttural fossa. This alone is enough to warrant tracheotomy, but its absence should not be construed negatively until a fossa-filling tumor has been excluded. This is done by palpation. Indrawing at the epigastrium is almost always present in children and is quite significant. The cardinal signs enumerated above are not present in cardiac, asthmatic, pneumonic or any kind of dyspnea other than that due to obstruction of the larynx or cervical trachea, hence they are diagnostic of a condition relievable by tracheotomy. Obstruction below this point may also call for tracheotomy, as for example when bronchoscopy has revealed an obstruction of the trachea or main bronchi by an endobronchial, murobronchial or peribronchial tumor or other lesion. Such lesions, invasive or compressive, call for tracheotomy so that air may, by suitably fitted cannulae, be piped down into either or both main bronchi.

Apart from dyspnea, tracheotomy may be indicated for *aspiration* in cases of flooding of the tracheobronchial tree by fluid threatening "drowning of the patient in his own secretions."<sup>6</sup> This applies only to children under two years of age and in them only in conditions that require frequent catheter aspirations (every few hours) by the nurse, for example, acute pulmonary abscess, acute laryngotracheobronchitis. In all other cases in children, and in all cases in adults, peroral broncho-

was done for the introduction of the bronchoscope. Improvements in instruments and in the technique of peroral introduction of the bronchoscope have entirely obviated the necessity for tracheotomy for this purpose, even in the newborn.

In the absence of dyspnea tracheotomy may be indicated as a preliminary to operations such as laryngectomy and pharyngectomy.

#### CONTRAINDICATIONS

When tracheotomy is indicated to prevent asphyxia there are no contraindications worthy of a moment's consideration. In other conditions it is contraindicated if bronchoscopy (always peroral) will serve the same purpose.

#### OBJECTIVE

Broadly speaking tracheotomy consists in a long median incision through all soft tissues overlying the cervical trachea, which is incised through the second and third rings. Through this incision a cannula for breathing is inserted.

In well-equipped hospitals tracheotomy has been largely removed from the emergency class by bronchoscopy. With a bronchoscope in situ the patient's breathing is easy and tracheotomy may proceed in an orderly way. The same end may be accomplished by the insertion of Mosher's intubational life saver of proper size. In hospitals less well-equipped emergency

tracheotomy will still be required as for centuries past. For these reasons consideration of both emergency and orderly tracheotomy are called for here.

#### ORDERLY TRACHEOTOMY

*Instruments.* An adequate equipment is as follows (Fig. 1):

Headlight.

Scalpels.

Curved, probe-pointed bistoury.

Tenaculum, special Chevalier Jackson model.

Two retractors.

Trousseau dilator.

Six hemostats (special Chevalier Jackson model preferable).

Scissors (dissecting).

Full curved needles, very small for suture ligatures.

Full curved needles (or clamps) for the skin.

Needle holder.

Suture material (or clamps).

Hypodermic syringe for local anesthesia with bent reinforced needle (special Chevalier Jackson model preferable).

No. 1 plain catgut ligatures.

Linen tape.

Gauze sponges.

Soft rubber catheter (10 F.) for aspiration.

Aspirator, preferably electrically operated.

Oxygen tank.

Tracheal cannula. (Fig. 8.) Size number 5 is suitable for adults, 4 for adolescents, 2 and 3 for children, 1 for infants. Duplicate (exact) will be needed in the after care.

*Preparation of the Patient.* As the operation is done under local anesthesia *psychic* preparation of the patient is important. He should be assured that the operation is not a serious one, that he will feel no pain and little discomfort; and especially he should be told that the operation will not take long, usually only a few minutes. It is well also to mention the fact that he may at times have his breath shut off; but that you know when this happens and you will not

keep it shut off too long. This psychic preparation along with proper local anesthesia will entirely obviate the necessity for resort to general anesthesia, which in dyspneic cases would needlessly introduce an element of great danger.

Local preparation need be no more than shaving in the ordinary way. The skin is sterilized on the table.

*Position of the Patient.* The best position is that shown in Figure 2.

*Enumeration of Steps.* (1) Preparation of the skin; (2) local anesthesia; (3) incision (hemostats applied as necessary); (4) dry dissection down to larynx and trachea; (5) disposition of the isthmus of the thyroid gland; (6) ligation of vessels; (7) tracheal fixation; (8) incision of trachea; (9) spreading of the tracheal incision; (10) insertion of the tracheotomic cannula; (11) closure of the incision; (12) dressing and drainage.

*Step 1. Preparation of the skin.* The surgeon may use his preferred method but there is probably nothing better than the usual manner with tincture of iodine followed by alcohol.

*Step 2. Local anesthesia.* Novocaine solution of standard strength is withdrawn from ampules directly into the hypodermic syringe. First the midline is injected from the hyoid bone to the suprasternal notch; then the deeper tissues of the midline. There is no need of going far laterally because flaps are not to be dissected up. Usually there is no need of any injection after starting. Instilling cocaine into the trachea is inadvisable; it seems better to allow the cough to clear the trachea and bronchi as soon as the trachea is opened.

*Step 3.* The *initial incision* in the midline from Adam's apple to the suprasternal notch passes through the skin and superficial fascia. Care is taken in the upper part of the incision to avoid cutting the external perichondrium of the laryngeal cartilages which are usually quite close to the skin. Integumentary vessels are clamped if necessary.

*Step 4. Dry dissection.* No flaps are dissected up. The incision is deepened in the

midline down to the thyroid, cricoid and tracheal cartilages, care being taken not to injure the external perichondrium, and not

*Step 6. Ligation.* Preparatory to the tracheal incision all hemostats must be taken off and a dry wound assured by

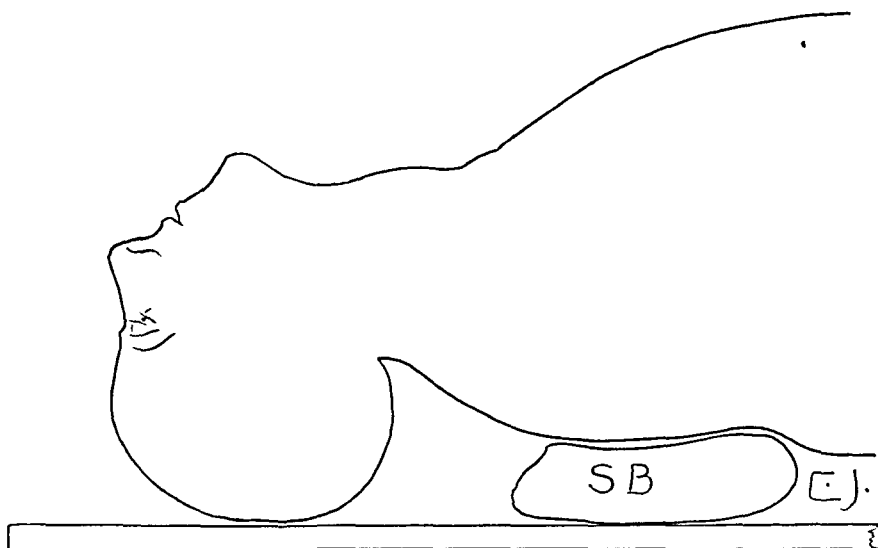


FIG. 2. Position of patient for tracheotomy. It is important that the sandbag be under the shoulders rather than the neck, in order to make the neck more prominent. If this position increases dyspnea, the head should be supported by the nurse, who sits on a stool at the head of the table. Her chief duty is to prevent the head from rotating, which would distort the cervical anatomy. The nose must point to the zenith.<sup>8</sup> (From "The Larynx and Its Diseases" by Jackson and Jackson, published by Saunders.)

to lay it bare except in the midline. The larynx and trachea should not be skeletonized. As in any orderly operation a dry wound should be maintained. There are no large arteries in the midline of the neck, but rather large veins may be encountered. They should be caught and cut off squarely between two hemostats. Nicks, slanted cuts or torn walls are likely to spring a leak later during cough.

*Step 5. Disposal of the thyroid isthmus.* The isthmus or even the thyroid gland must not be allowed to interfere with a properly placed incision of the trachea (see Step 8). Usually the most that will be necessary is to drag the isthmus upward or downward; but if this is not sufficient, the isthmus should be divided by a vertical median cut. If the cut ends ooze blood each end is quickly closed by a continuous overhand suture. If the isthmus is drawn upward or downward the direction of displacement must be remembered for finding the tracheal slit at the first few dressings.

ligature or torsion. Even slight oozing will result in a spray of blood droplets at each cough after the trachea is incised.

*Step 7. Tracheal fixation.* For a precise incision the trachea is first fixed with the tenaculum. As a rule the hook is passed through the interannular membrane at the lower border of the second ring, in the midline. With the hook under, not sticking in, the second ring, the trachea is lifted and thus fixed; its identity is also thus verified.

*Step 8. Tracheal incision.* The trachea is incised in the midline caudad from the hook of the tenaculum through the third, fourth and fifth rings. Caution is necessary to avoid incising the tracheo-esophageal party wall. The tracheal rings are really horseshoe-shaped because they are incomplete posteriorly. The membranous posterior wall is especially likely to be cut in children because of the small diameter of the trachea and especially because this small diameter is still further reduced by the mounding forward of the posterior wall

during cough. (Fig. 7.)<sup>19</sup> In adults the posterior wall does not mound forward much because of greater rigidity of the

there is a clot of mucopus expelled. If the dyspnea has been considerable the patient takes a deep breath that ends in a sigh of

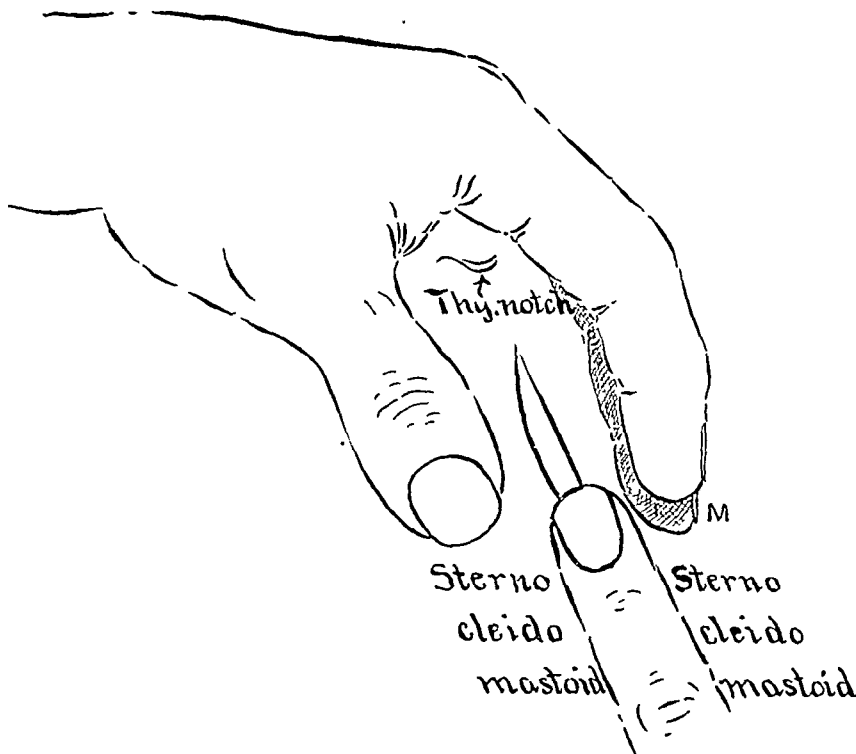


FIG. 3. Schema showing our method of rapid tracheotomy. First stage. The hands are drawn ungloved for the sake of clearness. The upper hand is the left, of which the middle finger (M) and the thumb are used to repress the sternocleidomastoid muscles, the finger and thumb being close to the trachea in order to press backward out of the way the carotid arteries and the jugular vein. This throws the trachea forward into prominence, and one deep slashing cut will incise all of the superficial tissues. Full length and depth of this primary incision are necessary to permit finger dissection down to the trachea. (From "The Larynx and Its Diseases" by Jackson and Jackson, published by Saunders.)

tracheal cartilages, but the accidental puncture into the esophagus is especially likely to happen from the plunging of the knife that has been pressed upon in order to cut through the partially ossified rings. Both these accidents are avoided by guarding the knife with the finger. (Fig. 6.) If preferred, only one ring may be cut with the scalpel and the others then cut with the probe-pointed, curved bistoury.

*Step 9. Spreading the tracheal incision.* Though there may be a hiss of air as the trachea is incised, the edges of the incision usually approximate so tightly that little air passes. The Trousseau dilator is inserted and the wound spread. Almost always

relief. A child worn out by a prolonged fight for air may fall asleep.

*Step 10. Insertion of the cannula.* To make sure the cannula enters the trachea the piloted distal end must be seen to pass in through the tracheal incision. The pilot is usually blown out by the tussive blast; if not, it should be quickly removed. The shield of the cannula, if the tube is of proper length, should stand out a little from the level of the skin.

*Step 11. Closure of the wound.* This may be done either with interrupted sutures or with clamps; but the most important thing is that the wound must not be closed completely, that is not close up to the



cannula. It is better to close only a short part of the upper and lower ends of the incision. (For reasons see *Pitfalls*.)

Step 12. *Dressing and drainage.* With

the signs of dyspnea and in the quick but gentle wiping away of the coughed out secretions before they are inspired into the cannula.

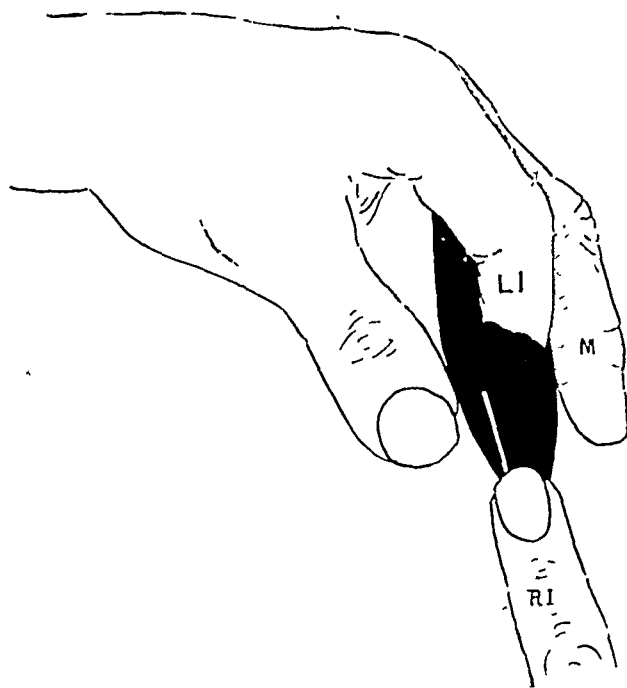


FIG. 4. Second stage of rapid tracheotomy. The fingers are shown ungloved as in Figure 3. In operating, the whole wound is full of blood and the rings of the trachea are felt with the left index finger (LI) which is then moved slightly to the patient's left, while the knife is slid down along the left index to exactly the middle tracheal line when the trachea is incised. If any difficulty is encountered in feeling the trachea the index finger should locate the thyroid cartilage and then burrow on downward onto the trachea, which of course is continuous. Incision is then made in the tracheal rings, preferably below the second ring. (From "The Larynx and Its Diseases" by Jackson and Jackson, published by Saunders.)

an open wound no drainage is necessary. A pad made of six or more layers of folded gauze is split halfway so as to go down astride the cannula back of the shield. Strips or small pieces of gauze are to be avoided because of the danger of an end getting into the trachea or cannula.

#### AFTER-CARE

At the top of the order sheet is written: "Opiates or atropine should not be given this patient."<sup>9,10</sup> The patient is put to bed with the usual postoperative nursing attention. If the nurse has not had good tracheotomic training she must be instructed in

Dehydration must be avoided. As no nauseating anesthetic or sedative has been given the patient may begin swallowing liquid food at any time. It is exceedingly rare that a feeding tube is required, but there is no contraindication to using it. The room should be well ventilated. In summer this will insure sufficient humidity in most climates. In winter, in the United States the air will require humidification. The outdoor air at, say, zero, contains almost no water; when this air is heated to 70°F. it becomes almost caustic to the tender tracheal mucosa of a child. Moistening of the air should be done without raising the

temperature over 70°F. because this defeats the object, by simultaneously raising the water absorbing power of the air. Mechanical humidifiers are best for this reason. A dusty atmosphere is to be avoided.

In the local care the keynote is "good plumbing." That is to say, throughout each twenty-four hours someone must be present who understands the necessity for and the means of maintaining clear "pipes," natural and artificial. And this person must understand that tracheotomy is not an ultimate object. The objective is to pipe air down to the lungs, and tracheotomy is only a means to that end. Secretions must not be allowed to accumulate and coagulate in the trachea; if they are not coughed out they must be aspirated. If crusts form they must be removed by bronchoscopy; sometimes coagula are so firm as to require forceps removal.

A bedside tray should contain the following:

Sterile gloves.

Sterile gauze.

Scissors.

Probe.

Hemostats (2).

Trousseau dilator.

Duplicate (exact) tracheotomic cannula.

Infant-sized catheter for aspiration.

A doubled 2-foot length of copper wire for pulling gauze through cannulae for cleansing before boiling. Wire gauge number 24 is heavy enough. Tonsil snare wire should not be used because it will damage the thin edge of the inner end of the cannula.

A mechanical aspirator and a tank containing oxygen (plus CO<sub>2</sub>, 5 per cent) should be in the room, ready for immediate use.<sup>14</sup>

A bronchoscope, bronchoscopic forceps, cords, battery and aspirating tube should be quickly available.<sup>7</sup>

Dressings are to be changed as frequently as soiled (usually every few hours). This has the effect of keeping the wound washed with sterile exuded serum, which is removed at each change of dressings.

The inner cannula is removed, cleansed in lukewarm sterile water and promptly replaced. The outer cannula should be

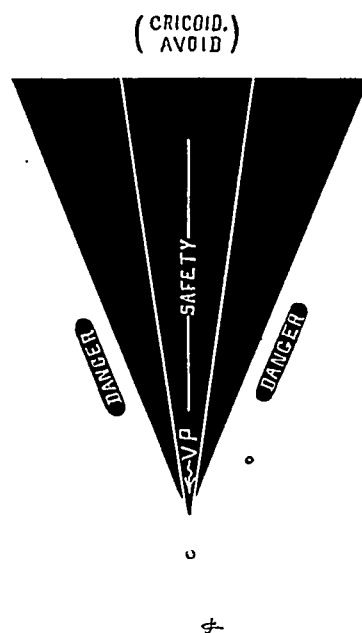


FIG. 5. Tracheotomic triangle for creating a mental conception of a safe and rapid technique for emergency tracheotomy. It has nothing to do with the cervical triangles detailed in textbooks on anatomy. The middle line is the safety line, the higher the wider. Below, the safety line narrows to the vanishing point, vp. The upper limit of the safety line is the thyroid notch until the trachea is bared, when the limit falls below the first tracheal ring. In practice the two dark danger lines are pushed back with the left thumb and middle finger as shown in Figure 3, thus throwing the safety line into prominence.<sup>4,8</sup> (From "The Larynx and Its Diseases" by Jackson and Jackson, published by Saunders.)

changed within six hours after operation to get rid of clots and inspissated serum; afterward at least once daily. There should be duplicate cannulae and they should be exact duplicates, so the inner cannula of either may be used in the changing of inner cannulae, and the duplicate outer cannula can be ready at all times for immediate substitution. Not only is delay avoided, but also the hasty cleaning that is so likely to be imperfectly done, with resultant damage to the inner end of the cannula. A damaged inner end causes endotracheal mucosal trauma and crusting, and it may lead to perichondritis of the tracheal rings.

The patient, if over 2 years of age, may be alarmed at inability to speak. He should be assured that this is only finger on the cannula. This may be demonstrated to him by the surgeon at a dressing.

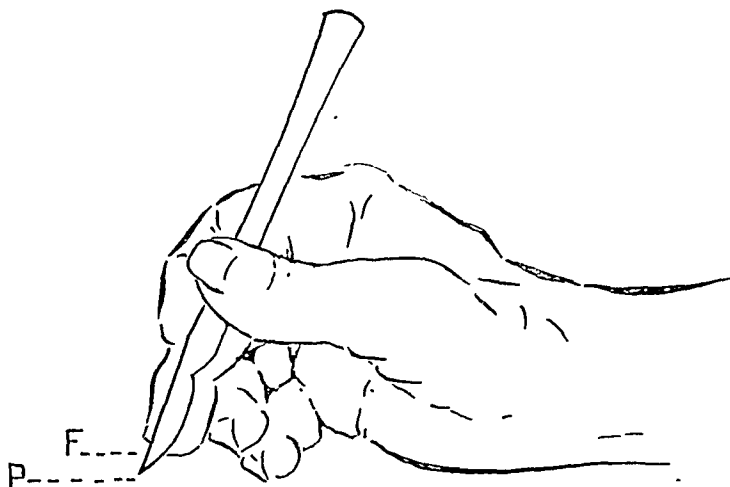


FIG. 6. Sketch showing finger guarding the knife during incision of the anterior wall of the trachea, to prevent puncture of the posterior tracheo-esophageal party wall. (Cf. Fig. 7.) The length of the blade from the point (P) to the finger stop (F) is so gauged that the point will not reach the tracheo-esophageal party wall, which is very close in children. The hand is ungloved for better delineation. (From "The Larynx and Its Diseases" by Jackson and Jackson, published by Saunders.)

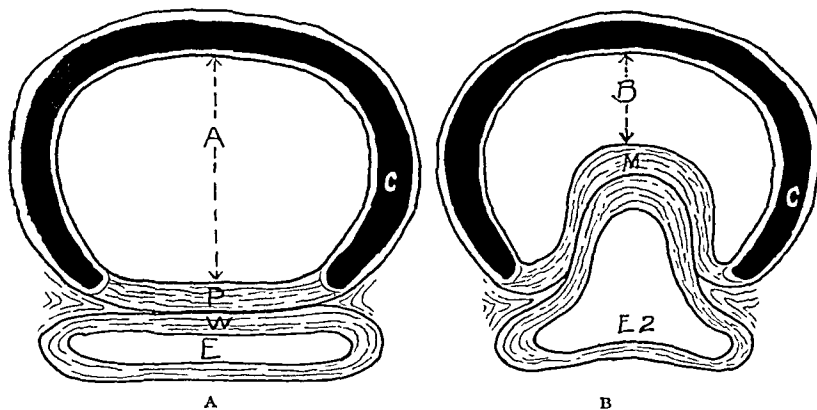


FIG. 7. Schema illustrating the mounding of the posterior tracheal wall during cough in children—a pitfall in tracheotomy. A, cross section of trachea during inspiration. c, horseshoe-shaped cartilage called a "ring." Between the heels of the horseshoe the posterior tracheal wall, p, is membranous and is integral with the anterior wall, w, of the esophagus, e, forming a "party wall," pw. During expiration the trachea diminishes in all diameters. During the forced expiration of cough the party wall, especially in children, mounds forward, diminishing by about half the anteroposterior diameter, a and b. When incising the trachea at tracheotomy, if care is not taken to stop the knife (Cf. Fig. 6), there is danger of the point of the knife penetrating through the thin party wall into the esophagus. This disaster is usually fatal from leakage of food and secretions into the trachea whence they are in-spirated into the lungs.<sup>19</sup>

because the air leaks out through the cannula, and that in about ten days he can talk as well as ever by putting his

The patient, if there are no complications or general contraindications may sit up on the third or fourth day and go about at the

end of a week. The wound may not be quite healed by that time, but there is then no danger of serious infection.

tion through the mouth into the larynx by the same motions used in O'Dwyer's method of intubation for laryngeal diph-

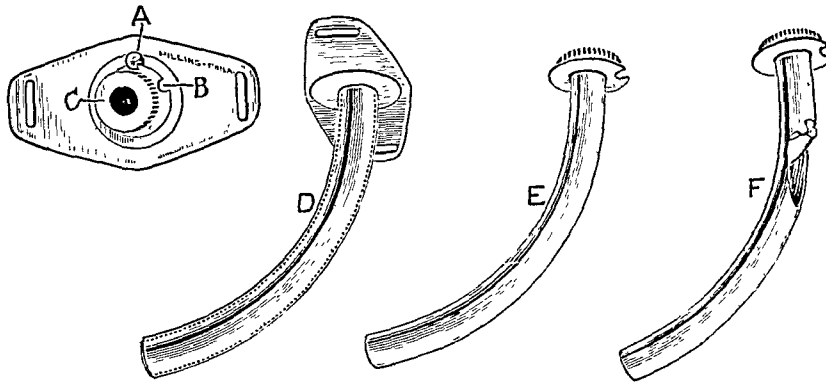


FIG. 8. Improved tracheotomic cannula devised by Chevalier L. Jackson. The shield in these cannulae is free from all obstruction. The advantage of this is that, in wiping the cannula with gauze to remove the secretions before the patient reinspirates them, there is no obstruction and no entanglement to catch the gauze. This is invaluable in the quick, proper and painless wiping of the cannula, especially in children. It is also useful in that there is no obstruction to the finger when it is desired to put the finger over the orifice of the cannula for speaking. Another advantage is that the very greatly lessened bulk in the front of the neck renders it very easy to hide the cannula under the clothing without any pressure of clothing on the cannula. These cannulae are made with the standard curve or any curve that may be required and of any length to fit the patient and the lesion, if tracheal. They are also made with a valve to facilitate talking and to facilitate fixation of the chest in using the arms. This valvular type of cannula is never to be used immediately after operation; in fact, not until a fistula has been formed by the healing of the wound around the standard cannula. The long cane-shaped cannula is made in rigid and vertebrated forms. The soft rubber pilot is a safeguard against making false passages, and, being hollow, it avoids terrifying the patient by shutting off his breathing during the introduction of the cannula.

#### EMERGENCY TRACHEOTOMY

The best technique of dealing with an asphyxiating patient is to insert a bronchoscope, establish regular respiration through it, and then proceed with a low tracheotomy in an orderly manner. In addition to elimination of hasty tracheotomy, this technique has the advantage of direct laryngoscopic and bronchoscopic inspection of the living pathology present in the particular case. Additionally, the bronchoscope in situ in the trachea makes the operation quite simple, by affording a staff that may be cut down upon. The conversion of an emergency into an orderly procedure can also be accomplished by use of Mosher's "life savers." These are curved tubes with a long straight shank for inser-

theria, though the instrument itself is quite different.

If, however, neither the bronchoscope nor the life saver is available an emergency tracheotomy must be done.

The quickest method that is certain in its results is the Chevalier Jackson two-incisions operation.<sup>11</sup> It is done as follows:

*Anesthesia.* Any patient needing an emergency tracheotomy does not need local anesthesia, and a general anesthetic would be promptly fatal.

*Instruments.* A knife and a pair of trained hands are enough, but a full surgical equipment as listed above is better.

*Position of the Patient.* The neck should be thrown into prominence by pushing a roll of fabric of any kind under the shoulders, close to the neck. If the patient is on the floor or pavement, or in a vehicle, the

head may be lifted and the neck brought above the left knee of the kneeling, or preferably, sitting operator.

*Technique.* For rapid performance it is well for the operator to ignore the details of anatomy and of orderly procedure above described; and to get instead a mental conception of the tracheotomic triangle. (Fig. 5.) He should get the conception of a windpipe in the midline covered by soft tissues through which he must cut, and can cut safely, so long as (a) the patient's head is not rotated, (b) the cutting is in the midline, (c) the operator's left index finger is educated to recognize the feel of the trachea, (d) the trachea is thrown into prominence between the operator's left thumb and middle finger. The throwing of the trachea into prominence should be rehearsed at every opportunity, such as on a member of the surgeon's family, a student, orderly or any patient whose neck is being examined. It is the most important feature of the procedure.

*Enumeration of Steps.* For clearness of description the procedure may be divided into seven steps; but in practice the steps merge into each other so rapidly and smoothly that it seems but a single procedure. (1) Feeling the trachea, fixing it, and throwing it into prominence. (2) Incision through the skin and superficial tissues. (3) Finding the trachea in the tissues and blood with the left index finger. (4) Incision of the trachea. (5) Holding open the slit in the trachea, or insertion of a cannula. (6) Reestablishment of respiration. (7) Hemostasis.

*Step 1.* Throwing the trachea into prominence and fixing it in the midline are accomplished by pushing back the great vessels well under the sternomastoid muscles. This is done in a second or two with the thumb and index finger of the left hand. (Fig. 3.)

*Step 2.* With one sweep of the scalpel an incision is made from Adam's apple almost to the suprasternal notch. This incision must go clear through the skin to facilitate free finger dissection. There may

be considerable flow of blood but nothing immediately dangerous.

*Step 3.* Finger dissection to find the trachea. (Fig. 4.) While the left thumb and middle finger are still holding back the great vessels under the sternomastoids the previously idle left index finger quickly locates the trachea by following downward from Adam's apple. The trachea is infallibly identified by the ridgy character of its walls; there is nothing like it in that region. Every medical student has learned, or should have learned the feel of it in the dissecting room. In identifying the trachea the finger at the same time bares its midline of tissue below the cricoid, by pushing aside any overlying tissue; if the isthmus of the thyroid gland intervenes it is pushed downward or pulled up. If it is torn or cut it will not matter. If an anomalous artery is felt crossing the trachea at this point it is pushed down or pulled up.

*Step 4.* Tracheal incision. The trachea having been identified and bared of tissue, the tip of the index is slid slightly to the operator's left side so that the scalpel in the right hand can be safely guided down along the palmar surface of the index onto the tracheal wall. Two or three rings are incised. In making the incision the middle finger of the right hand makes a guard against deep entrance of the knife that might otherwise go through the posterior tracheal wall into the esophagus.<sup>19</sup> (Fig. 6.)

*Step 5.* Holding apart the lips of the tracheal incision. There is usually a hiss if the patient is breathing, but the lips of the tracheal incision in most cases lie so closely in contact that insufficient air is permitted to pass. The lips should be spread apart with a Trousseau dilator; if none is available a hemostat will do. Lacking these, the handle of the scalpel may be inserted in the slit and rotated slightly to cause gaping. Of course some blood will trickle into the trachea but cough will quickly expel it and spray it about. The cannula is inserted with its pilot; the pilot is removed if not blown out by the tussive blast. If by reason of deplorable lack of equipment no cannula

is available someone must hold the lip of the tracheal incision apart until a cannula can be obtained or a makeshift devised for temporary use.

*Step 6.* Artificial respiration must be done if there has been respiratory arrest. Oxygen mixed with 5 per cent carbon dioxide should be liberated at the tracheal opening or greatly insufflated through a catheter. Vaporized amyl nitrite is a good stimulant if the pearls are at hand, as they should be.

*Step 7.* Hemostasis. As soon as respiration is established hemostasis may be done in the usual way. If artificial respiration is necessary temporary hemostasis may be afforded by packing gauze firmly into the wound and around the cannula.

*Difficulties and Pitfalls of Tracheotomy.* If the technique given has been closely followed there will be no serious difficulty. Departure from the technique involves risk of pitfalls. A common one is the attempt to give a general anesthetic. Dyspneic patients are dependent largely on the aid of the accessory muscles of respiration under voluntary stimulus. This is abolished as soon as loss of consciousness begins; respiration ceases and unless bronchoscopy or tracheotomy is done within two minutes the respiration cannot be started and the patient asphyxiates. In the aggregate the mortality from this pitfall has been enormous. General anesthesia should never be used for tracheotomy unless a bronchoscope is in situ; and there is no need for it even then. It may be added that opiates for the restlessness of air hunger in children needing tracheotomy have often precipitated an emergency tracheotomy, and in many cases have resulted in death by asphyxia.<sup>4,9,11,13</sup>

A *short incision* is a common pitfall. A long incision gives ample access and this renders the operation easy.

*Complete closure of the wound*, close up to the cannula, is a pitfall of not infrequent occurrence. A false passage by the cannula going astray may occur at any of the early dressings, and lead to a slow asphyxia.

With an open wound the tracheal incision can be found with the Trousseau dilator and the cannula can be seen to enter the trachea.

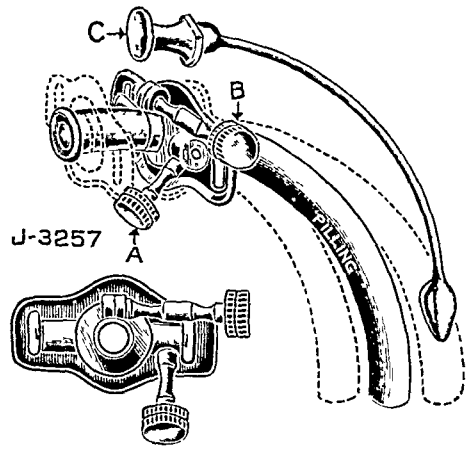


FIG. 9. If a cannula is to be worn more than a few days it must fit perfectly, as otherwise it will cause erosion, ulceration, crusting, hemorrhage and perichondritis. The measuring cannula (C. L. J.) here shown is used to determine the radius of curvature and length of tube and the shield angle.<sup>18</sup>

*Mediastinal emphysema* is usually due to stitching the wound close up around the cannula. The air in the cervical tissues works downward between the layers into the mediastinum. This pitfall can be avoided by packing the wound open as indicated above. Rarely the air may leak into the pleural cavity causing a *pneumothorax*. Spontaneous pneumothorax has occurred from rupture of the visceral pleura in violent respiratory efforts in impending asphyxia.<sup>11</sup> This may be favored by old adhesions. Unilateral pneumothorax in such cases is rarely followed by empyema and the lung reexpands normally. Bilateral pneumothorax is quickly fatal unless bronchoscopic oxygen insufflation is promptly instituted and constantly maintained until at least one lung has expanded. Pneumothorax may occur from direct trauma to the pleura in an excessively low tracheotomy.<sup>15</sup>

*Hemorrhage in Emergency Tracheotomy.* We are indebted to Batson for the knowledge of the anatomic fact that there may be, anomalously, a large artery in the

midline of the neck, but the chance of encountering it in a patient needing an emergency tracheotomy is exceedingly remote. The dissecting finger would quickly detect such a vessel and the finger could not tear it open with any force a surgeon would apply. The finger feels the bared tracheal rings before incising them. If such an anomalous artery should be cut, of course, the surgeon would seize the squirting artery with a hemostat. Obviously the surgeon must be aware of even rare anatomic anomalies, but because of a possibility so remote no patient should be allowed to asphyxiate for want of a prompt emergency tracheotomy.

Pneumonia after tracheotomy is one of the curiosities of medicine. The high frequency of this complication in the literature is due to mistakes of diagnosis. The often fatal pulmonary condition is really an *obstructive atelectasis* completely relivable by bronchoscopic methods. Hundreds of times we have had it reported to us that our tracheotomic patient was "dying of pneumonia." Prompt bronchoscopy almost invariably revealed plugs of thick secretion, or crusts, or both, obstructing bronchial orifices. Bronchoscopic removal caused disappearance of the fever, high respiratory rate and impaired percussion note on which the erroneous diagnosis of pneumonia had been based. Auscultation is not so misleading in these cases.

Pneumonia is an exceedingly rare complication of tracheotomy. If it really does occur bronchoscopic aspiration should be added to medical care and management.

*Laryngeal and tracheal stenoses* are usually due either to a high tracheotomy or a misfit cannula, two pitfalls that are easily avoided. Tracheotomy should be done below the first ring of the trachea. If this is done there will be no stenosis caused by the tracheotomy.<sup>2,17</sup>

All patients requiring prolonged wearing of a tracheotomic cannula should have the cannula checked for perfect fit.<sup>17</sup> A misfit cannula will cause erosion of the tracheal mucosa, perichondritis and chondral necro-

sis. If the Roentgen ray shows the cannula has too short or too long a radius of curvature a perfectly fitting cannula must be made from measurements best obtained with the measuring apparatus shown in Figure 9.<sup>18</sup>

Stenosis also occurs from destructive processes of the primary disease, for example diphtheria, syphilis, tuberculosis, typhoid fever.<sup>12</sup> When the cartilaginous framework is destroyed, even partially, the unresisted cicatricial contraction will obliterate the laryngotracheal lumen. This must be frustrated and the lumen restored by the early use of core moulds.<sup>17</sup>

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SURGERY was born of a queer muddle of demonology, tribal ritual and social necessity, but in the earliest civilizations it developed rapidly into a lusty infant art.



# NON-OPAQUE FOREIGN BODIES IN THE ESOPHAGUS

## WITH REPORT OF FOUR CASES

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IN spite of the numerous articles which have appeared in the literature regarding the swallowing of foreign bodies, not infrequently these emergency patients are examined by certain methods which are unsatisfactory, unscientific and occasionally fraught with extreme danger to the patient. It has been our experience that, before a patient with an impacted foreign body in the esophagus consults a laryngologist, he has usually been subjected to several incomplete examinations.

All these patients give the history that while eating meat or fish they felt something stick in their throat which caused them to gag and retch. They immediately resorted to drinking fluids, eating soft bread or potatoes, and were slapped on the back, in an attempt to dislodge the foreign body. Occasionally following these efforts all symptoms disappeared. Often a lump, pain, scratch, or a "feeling of something there" persists in the throat or esophagus, and the patient consults a doctor. The foregoing symptoms may be mild or severe, constant or present only on swallowing. Pain is often referred to the back or to one or both shoulders. The attending physician must decide whether the foreign body has passed into the stomach, causing only an abrasion, or is still lodged in the lumen of the esophagus and in danger of perforating its wall. He must also consider the possibility of dealing with an unduly alarmed individual.

Routine investigation of these patients consists of a search of the pharynx and larynx, sometimes with and frequently without the use of a mirror. Occasionally patients will insist on an x-ray examination, for the public has been educated to the

infallibility of the Roentgen ray. If these examinations prove negative for foreign body in the esophagus, then the patient is advised to "forget about it," or to swallow dry bread, potatoes, etc. Sometimes blind bouginage is resorted to. These patients then, if they still complain of pain on swallowing, are tacitly labelled "neurotic." This latter diagnosis may be correct, but not infrequently a foreign body is present, and it seems unjustifiable to allow the few to suffer, because of the mental worries of the remainder.

Although endoscopists have advocated and preached the gospel of the wider use of the bronchoscope and the esophagoscope, both in diagnosis and treatment, yet there is considerable reluctance on the part of our medical colleagues in recommending such an examination. For some reason or other, the idea of a fearful and terrible ordeal has been associated with these examinations, and laryngologists may be responsible for some of this. The technical difficulties of these procedures have been overstressed.

It is our feeling that the bronchoscope and esophagoscope should be used much more frequently, in conjunction with all the other accepted methods of examination. This includes a careful and reliable history; a thorough search of the mouth, tonsils, pharynx, nasopharynx, base of tongue, larynx, and pyriform sinuses by direct vision in a good light; and the use of a laryngeal mirror. Fluoroscopic studies of the esophagus should be included, with thin and thick barium mixtures and barium filled capsules. No one method of diagnosing a non-opaque foreign body in the esophagus is 100 per cent accurate, and all of them should be used more freely. We

doubt the advisability of leaving esophagoscopy until the last, or until all other methods fail to reveal the foreign body. The use of the esophagoscope is not only an excellent method of diagnosing foreign bodies, but carries with it a means of treatment which is usually curative.

These points are all well illustrated in the following cases. In the first and second cases the history was suggestive, the x-ray negative, the patient insistent and esophagoscopy diagnostic and curative. In the third case the patient was insistent, the fluoroscope suggestive, but the esophagoscope negative. A repeat fluoroscopy with heavy barium was again suggestive. X-ray films were positive for retained barium, probably on the foreign body. An immediate esophagoscopy was the direct means of a diagnosis and successful treatment. In the fourth case all examinations, including esophagoscopy, were negative, and the pathologist had to make the diagnosis.

#### CASE REPORTS

**CASE I.** Miss B., age 25, a single school teacher, had swallowed what she thought was a chicken bone, which seemed to lodge about half way down the esophagus. Almost immediately she had pain in the right axilla, which was aggravated by swallowing. Fluoroscopic studies with heavy barium revealed no evidence of obstruction, and the patient was allowed to go home. She returned the following morning without any improvement of her symptoms, the most outstanding of which was the pain in the right axilla on swallowing. An esophagoscopy was performed and a bone was found lying at the upper constriction, bifurcating the esophagus and probably allowing the barium and capsules to pass unimpeded. The axillary pain disappeared shortly after, and the patient made an uneventful recovery.

**CASE II.** Mrs. L., age 51, a scrub woman, while eating supper developed a sudden pain in the neck radiating to the back. The pain persisted but there was no particular difficulty in swallowing. The patient consulted a hospital where examination and x-rays of the throat were pronounced negative. She remained in

hospital three days, and the pain in the neck was explained on an arthritic basis.

On the fourth day the patient was seen in

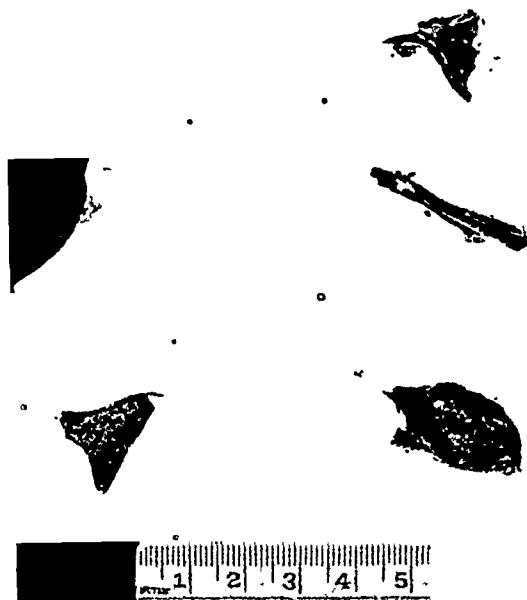


FIG. 1. Non-opaque foreign bodies removed by esophagoscopy.

this hospital because of persistence of the pain. Examination under the fluoroscope with light and heavy barium mixtures and barium capsules revealed no esophageal obstruction. An esophagoscopy revealed a bone in the upper part of the esophagus. This bone extended from behind forward, divided the esophagus into equal parts, and evidently allowed the barium to pass without detection on fluoroscopy.

**CASE III.** Mrs. H., age 34, while eating roast beef for supper, swallowed a bone. She noted something stick in her throat while swallowing, and her throat bled slightly. Severe pain under the sternum and in the left shoulder persisted. The referring physician noted on examination with barium that a lag of the column of barium occurred on fluoroscopy at the upper end of the esophagus. About midnight, the patient was carefully examined with an esophagoscope, but the foreign body could not be located. The pain was very persistent, was relieved by morphia, and was still present the next morning. Fluoroscopy again disclosed a lag of the barium column at the upper end of the esophagus, and x-ray film showed a small fleck of barium retained. A second esophagoscopy was done, which revealed, after careful search, a small bit of barium on the posterior wall of the esophagus. The barium could not be wiped off, and on grasping with

forceps the free end of the beef bone was discovered and the bone removed.

Apparently the beef bone was lying in the coats of the esophageal wall, or projecting into the mediastinum. This lady was relieved immediately of her major pain, and recovery was uneventful, though she was watched with some misgiving for several days.

CASE IV. S. C., age 20, a young business man, while eating chicken for supper, felt something sharp stick in his throat. At first it seemed to lodge in the upper part of the esophagus, but at the time of his first examination it was felt nearer the stomach. On swallowing, pain was felt in the region of the xiphoid process.

Examination of the throat and fluoroscopy with barium mixture were negative for a retained foreign body. Esophagoscopy showed some injection of the mucous membrane in the mid-thoracic region, but no foreign body could be seen. This patient was kept on sterile fluids and closely observed for a week with symptoms gradually abating. Ten days later the patient stated that all symptoms had disappeared and

he was feeling fine. A week later he suddenly bled to death in his bathroom. A coroner's autopsy disclosed a traumatic perforation of the aorta following a perforation of the esophageal wall by the chicken bone.

#### COMMENT

All patients giving a history of swallowing a non-opaque foreign body should have a careful examination, including esophagoscopy. The accompanying photograph of osseous tissue non-opaque on Roentgen ray examination (Fig. 1) makes us realize that these patients do have a cause for their severe symptoms, and yet our ordinary examination without esophagoscopy may fail to reveal this foreign body. The four case reports presented indicate the seriousness of swallowing foreign bodies, and warrant the conclusion that complaints arising in patients giving this history, demand immediate and exhaustive investigation.



# FRACTURES AND DISLOCATIONS OF THE JAWS AND WOUNDS OF THE FACE

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THE management of injuries to the face and jaws has engaged the attention of the general surgeon and the specialist throughout the history of surgery. In the past few decades, however, the incidence of facial injuries has gradually increased and their care has placed an additional demand upon the profession.

In the treatment of facial injuries, the surgeon's concern should be to minimize facial disfigurement and restore function. That the importance of these factors is not fully appreciated is frequently seen in results obtained. The careless approximation of skin edges, the use of large needles and suture material and the failure properly to debride wounds are inexcusable mistakes. Sensitiveness to facial disfigurement varies with different individuals and what may be an ineradicable complex throughout life to one may be a source of pride to another but can well be an economic handicap to both. Therefore, it is demanded of the surgeon that these injuries be repaired to the best of his ability and as far as circumstances, often difficult, will allow.

## ETIOLOGY

Fractures of the jaws are either traumatic or pathologic, the latter being relatively rare. At the present time, automobiles are responsible for the greatest number of cases, with fist fights, industrial accidents, falls, etc., following in the order given. In addition to being fewer in number the latter cases are usually less severe.

## DIAGNOSIS

In the simple, clear-cut case there is usually no difficulty in establishing the diagnosis, but in the more severely injured cases a detailed clinical examination fol-

lowing a systematized plan is necessary to determine the extent of the injury. As a guide in so doing, the following points should be observed:

1. External injuries of the face, including lacerations, contusions, swellings and ecchymotic areas. Fractures of the mandible may occur at the point of application of the trauma or at some distant point to which the force is transmitted through the bone.

2. Asymmetry in the contour of the face. Flattening of the facial features on one side just below the outer rim of the orbit suggests a depressed fracture of the malar bone. Digital palpation of the orbital rim and zygomatic arch will disclose irregularity at the site of fracture of these structures. Since these fractures are all due to direct trauma, anesthesia of the infra-orbital nerve on the affected side is a common sequelae. Depressed fractures of the zygomatic arch may interfere with the forward excursion of the mandible in attempted opening of the mouth.

3. Palpation of the temporomandibular joints. With the index fingers in the external auditory meatus, pressing anteriorly, the action of the condyle is felt in the opening and closing movement of the mandible. Fracture of one or both condyles precludes movement of the articular head. Associated deformities from condylar fractures are shortening of the vertical length of the ramus on the affected side and depression of that area of the face over the joint when the condylar head is displaced.

4. Examination of the oral cavity with especial reference to the occlusion of the teeth. Any alteration of relationship between the upper and lower teeth is indicative of fracture with displacement. Unusual

mobility of several contiguous teeth suggests fracture of the alveolar process. Compound fractures are easily recognized



FIG. 1. Dental splint fitted to the arch with an extension to engage the posterior fragment and prevent its being displaced upward by the elevator group of muscles. After adjusting the splint the jaw should be immobilized.

by a break in the mucoperiosteum. Palpable tenderness is usually present at the fracture site and crepitus is a valuable diagnostic sign.

5. Other objective and subjective symptoms. These include areas of anesthesia resulting from nerve injury such as occurs to the lip in mandibular fractures, loss of function and infection.

#### ROENTGENOGRAPHIC EXAMINATION

Fractures of the jaws are occasionally overlooked because of inadequate Roentgen examination. This is one of the most valuable diagnostic aids, but should not be used to the exclusion of other diagnostic measures.

The horizontal portion of the mandible, excluding the symphysis, is best shown in the lateral position. The symphysis is best demonstrated with a large intraoral film,  $2\frac{1}{2} \times 3\frac{1}{4}$  inches, placed between the occlusal surfaces of the teeth and the rays directed from below the chin. An antero-posterior projection is necessary to demonstrate the rami of the mandible and the condylar relationships.

Fractures of the maxillae are more difficult to demonstrate radiographically than

are those of the mandible. Roentgenograms made in the Waters position of the bones of the upper face will give the best visuali-

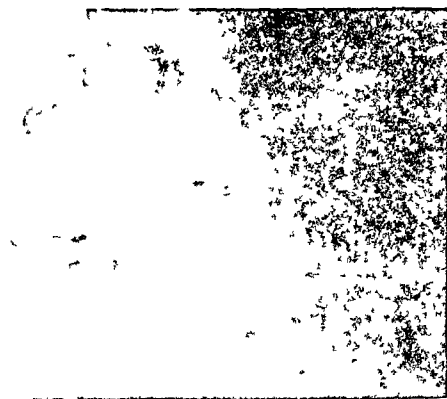


FIG. 2. A fractured tooth in the line of fracture. This tooth was allowed to remain in position to prevent elevation of the posterior fragment. The injured tooth was removed as soon as the posterior fragment was retained by fibrous union.

zation of these structures. The zygomatic arch and malar bones are best outlined with the skull in the vertical position.

In addition to showing the presence of a fracture the Roentgen examination will disclose such additional information as the direction of the fracture line, fragmentation of the bone, presence of foreign body in the fracture line or adjacent tissues, injuries to the teeth and position of fragments after reduction.

Poorly angulated and processed x-rays may be very misleading and only those without distortion and clear-cut as to detail should be accepted as a basis for diagnostic deductions.

#### TREATMENT

Generally speaking, the earlier reduction is done the better, but the nature and extent of the injury often precludes other than emergency treatment. If the wound is contaminated with dirt or other foreign substance 1500 units of tetanus antitoxin is administered. Hemorrhage is controlled and lacerations of the skin and mucous membrane closed. The Barton bandage, commonly applied as a temporary means

of treating mandibular fractures, is inefficient when there is displacement. The backward pressure exerted on the chin by the bandage only produces more displacement and pain.

*Mandibular Fractures.* With but few exceptions the restoration and maintenance of occlusion between the upper and lower teeth is all that is necessary in the reduction of fractures of the mandible.<sup>1</sup>

The first exception is a fracture at or near the angle of the jaw and lacking a tooth in the posterior fragment. The elevator muscles tend to displace the posterior fragment upward. Many methods are available to control this displaced posterior fragment, such as direct fixation of the bone, or a dental splint as described by Schaeffer and Skinner,<sup>2</sup> with an appropriate extension beyond the line of fracture and forked over the bone to hold it in position. (Fig. 1.) Every effort should be made to conserve a tooth in the posterior fragment. Even though it may be damaged or its roots be in the line of fracture it will in all probability serve to control the posterior fragment until no further fixation is necessary. (Fig. 2.)

The second exception consists of fractures of edentulous mandibles. With slight displacement, insufficient to cause non-union or deformity, no treatment is indicated other than rest. Amends for the resulting irregularity of the alveolar ridge can be made with artificial dentures. If the displacement is marked, reduction is effected by direct bone fixation or by circumferential wiring. For direct bone fixation an incision is made along the lower border of the mandible immediately below the fracture. The fracture line is exposed and debrided. Holes are drilled through the bone about 1 cm. from the fracture line and if the size of the mandible will permit, two holes are placed on either side of the fracture. A 22 gauge silver wire is laced in a criss-cross fashion between the holes, the reduction made and the wires tightened. Care should be exercised in the tightening process to see that the wires are not tight

enough to cause pressure resorption, but yet are tight enough to hold the fragments in approximation. If the fracture is compound the wound is closed with provision for drainage, otherwise not. The wire may or may not be left in permanently, depending upon the progress of the healing. If no infection occurs and if the presence of the wire does not interfere with denture construction, there is no positive indication for its removal.

With circumferential wiring, 25 gauge soft silver wire or any other suitable ligature wires are passed around the mandible, one on either side of the fracture line and tightened over a saddle-like splint which has previously been fitted to the ridge. The lower denture serves as a satisfactory splint. This method has the disadvantages of not giving the exact reduction and approximation of the fragments that is afforded by the open view method and causing the discomfort of wearing the splint. Traumatic ulceration of the soft tissue will develop as a result of impinging the mucoperiosteum between the bone and the splint.

By the large, intermaxillary fixation is the method of choice for treating fractures of the mandible. Reduction and fixation has been greatly simplified by the use of intermaxillary rubber band traction. This method of treating the jaw fractures is a distinct advance over the generally employed method of using wire alone for interdental ligation. In many clinics, including our own, it has largely supplanted all other methods, especially if a sufficient number of teeth are present in both jaws. It entails nothing more than the attachment of small aluminum shells, described by Woodward,<sup>3</sup> to the teeth of the upper and lower jaws with 25 gauge stainless steel wire and attaching the rubber bands between the opposing shells of the upper and lower teeth. The mechanism thus employed for reduction serves equally well for immobilization. The fragments are held in apposition with slight movement, which materially aids repair. This factor, com-

bined with ease and simplicity of application, elimination of manipulation of fragments, and provision for good dental

be made to keep these incisions beneath the shadow line of the mandible to avoid unsightly scarring.



FIG. 3. Arch bar wired to the teeth. Continuity of the bar is broken at the site of fracture and the rubber band traction adjusted between the upper and lower bars. The rubber bands serve equally well for immobilization and for reduction. (Dingman.)

hygiene is testimony to the value of the method.

If the teeth are insufficient in number or stability a half round 16 gauge German silver arch bar wired to the buccal surfaces of the teeth, will provide sufficient attachment for rubber bands to effect reduction. (Fig. 3.)

The great majority of mandibular fractures are compounded to the mouth in consequence of which they are liable to infection. Some advocate the establishment of drainage in all such cases at the time of reduction by making a stab wound immediately below the fracture line. Since less than one-half of such cases become infected it would seem more conservative to treat the infection, if and when it occurs, by localizing and draining the abscess with an extraoral incision at the most dependent point of the swelling. Efforts should always

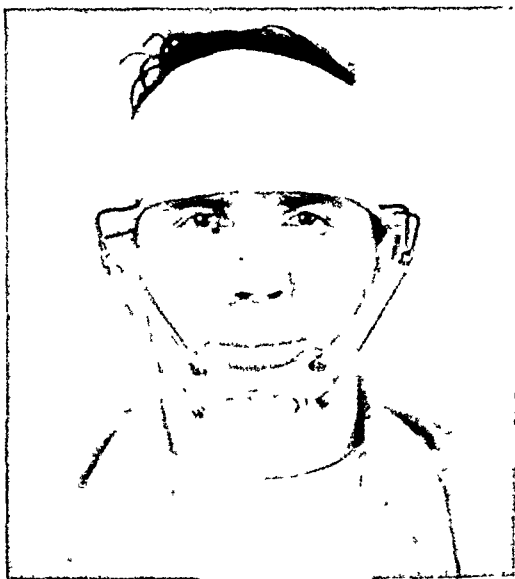


FIG. 4. Aluminum chin cap attached to plaster of Paris head cast with long rubber bands to reduce and maintain in position a transverse fracture of the maxilla. Normal occlusion is effected and maintained throughout the healing process.

Fractures of the condyle and rami are as amenable to the rubber band method of reduction as are fractures of the body of the mandible. Fractures through the neck of the condyle with displacement require three to four weeks of immobilization. Even though the condylar head is displaced from the glenoid fossa, open reduction is contraindicated. Ankylosis is not a sequela of condylar fractures unless the joint surfaces are involved. Open reduction is hazardous and unwarranted.

*Fractures of the Maxilla.* Upper jaw fractures vary in extent from simple fractures of the alveolus to complete separation of the bones of the face from the skull. The fracture may be unilateral or bilateral and it may involve the maxilla at any level. In complete transverse fracture the bones of the face move as a unit on manipulation and require fixation outside of the mouth for immobilization.

Unilateral fractures of the maxilla are reduced by intermaxillary fixation using

only the unaffected side if the displacement is downward. The constant pressure exerted by the rubber bands will gradually force the displaced fragments back to normal position. If displacement is upward and backward and of the impacted type the traction is applied to both sides and the displaced fragment is brought down until the teeth contained therein occlude with the teeth of the lower jaw.

Complete transverse fractures if displaced downward are reduced by encircling the mandible with slight elastic tension attached to a skull cap. This cap may be of plaster of Paris or it may be a regular surgeon's cap. If the former is used a chin cap, swedged from aluminum and lined with felt with four posts attached, one at each corner, can easily be utilized to exert an upward pressure by attaching long rubber bands between the plaster of Paris head cap and the chin cap. (Fig. 4.) Care must be exercised in the amount of upward pressure applied, as many of the fractures are comminuted and complicated by cranial injury.

If either or both of the jaws are edentulous, the most efficient method of supporting the bones is by the use of a splint adapted to the upper jaw to which side arms are fastened and curved to extend from the corners of the mouth and posteriorly along the face. (Fig. 5.) Adhesive strapping is attached to the extended arms and fastened over the vertex of the skull. An upper denture makes a satisfactory splint to which the arms may be vulcanized.

*Depressed Fractures of the Malar Bone and Zygomatic Arch.* These fractures are always due to direct force and the malar bone, usually fractures at or near its juncture with other bones. The deformity is characterized by depression of the facial contour below the outer border of the eye. Correction should be effected as soon as possible after the injury, as union in malposition occurs rapidly. Of the many methods advocated for raising the depressed bone the intra-antral gives uniformly good results. It has the added

advantage of clearing the antrum of all blood clots and providing adequate drainage. The antrum is opened through its



FIG. 5. Cast metal splint covering the upper jaw and palate to which side arms are attached and extended from the corner of the mouth backward over the face. Adhesive strapping is employed to attach the splint to a plaster of Paris skull cap. This method is not advisable if both upper and lower teeth are present as the splint interferes with obtaining normal occlusion of the teeth.

outer anterior wall and the bones elevated to their normal position. It is rarely necessary to pack the antrum to maintain the bones in position unless the structures are badly shattered. The Gillies<sup>4</sup> method is also very useful, especially so if the zygomatic arch is also depressed. Through a short, transverse incision made above the hairline, in front of the ear, a long, flat periosteal elevator is forced below the malar bone, keeping it just outside the temporal muscle. By padding the head above the shank of the elevator and using it as a fulcrum, the necessary elevating pressure can be produced. The short incision is closed and leaves no visible scar as it is above the hairline.

#### MANDIBULAR DISLOCATION

When the jaws are closed or at repose the head of the condyle is in the glenoid



fossa. Interposed between the head of the condyle and the roof of the fossa, and dividing the joint into two separate synovial cavities, is an interarticular disc or pad. As the jaw opens, the condyle, together with the interarticular disc, glides forward until it rests under the eminentia articularis. If the jaw is forced beyond this point it may become locked, thus constituting the usual anterior dislocation. In addition to the anterior dislocation, Blair and Ivy<sup>5</sup> have described superior, posterior and lateral dislocations. They are of such infrequent occurrence that mention is only made in passing. Dislocations may occur as the result of injury or by forcibly opening the mouth beyond its normal limits. Dental extractions and throat operations under general anesthesia in which the mouth is too widely opened with a gag are frequent causes.

*Symptoms.* In unilateral dislocations the chin is deviated to the unaffected side while in bilateral dislocations the chin will be well centered but in a protruded position. The patient is unable to open and close the mouth and the teeth are in malocclusion. Palpation and x-ray examination disclose the condyle well in advance of the articular eminence and a depression is felt in the area of the joint. Dislocation differs from fracture in that in the latter some of the teeth may be in occlusion or can be brought into occlusion by manipulation.

*Treatment.* In cases of not too long standing reduction is accomplished by downward traction at the angles of the jaw with pressure exerted posteriorly. At the same time the chin should be slightly raised, thus reversing the movement that the condyle undergoes while leaving the socket. This manipulation is performed by placing the thumbs, protected by gauze, over the occlusal surfaces of the bicusps and molars and the fingers under the chin. In protracted cases, open reduction may be necessary.

After reduction the opening movement is limited for several days by bandaging

the jaws with a Barton bandage or if teeth are present by interdental ligation.

#### WOUNDS OF THE FACE

Fractures and dislocations of the jaws are frequently accompanied by wounds and lacerations of the face. With the highly competitive struggle for present day existence and the psychological effect of ugly scars and deformities it is demanded of the surgeon that he acquaint himself with the details of repair of these facial wounds to obtain a pleasing result or refer the patient to one adequately trained in this field of endeavor.

The toilet of the wound is the initial consideration. All facial wounds are potentially infected and should be thoroughly cleansed with tincture of green soap and water followed by a thorough irrigation of normal saline solution. This also holds true for excoriated surfaces in which dirt and foreign material may be ground and which if allowed to heal will give the skin a tattooed appearance. The wound should be inspected for bits of foreign material all of which should be removed. As in fractures that are suspected of being contaminated, a prophylactic dose of 1500 units of antitetanus serum and 1250 units of gas bacillus serum is administered after testing the patient for horse serum sensitivity.

After the toilet of the wound is completed and bleeding controlled it is ready for closure. If the wound edge is ragged and irregular it is straightened by excising the ragged edge. Likewise, contused wound edges, liable to undergo necrosis, are excised to bring healthy tissue into approximation. The wound edges are undermined in order to approximate them without tension. To facilitate suturing and minimal scar formation the skin edges should be vertical.

Suture material should be of fine gauge and non-capillary in action. The needle should be of the nontraumatic type. The subcutaneous tissue is closed first with interrupted sutures cut short. The skin is then closed by interrupted sutures, closely

placed with considerable attention paid to approximation of the skin edges or by a running subcuticular stitch as described by Lange.<sup>6</sup> In using the latter, the suture material should be brought to the surface each  $\frac{3}{4}$  inch, to allow for cutting during removal.

If there has been considerable undermining of the tissue a pressure bandage should be applied. Gauze, held firmly in place with roll bandage, is adequate. Where no pressure is required a gauze collodion dressing over the wound is adequate, more comfortably tolerated by the patient, and provides some support to the wound edges. Areas denuded of the superficial epithelium are covered with gauze impregnated with an antiseptic ointment.

The early removal of sutures is imperative for minimal scar formation. Interrupted skin sutures should be removed on the third or fourth day. Removing alternate sutures on the third day and the remainder on the fourth is a safe procedure.

The extent and location of lacerations together with the presence or absence of infection are the deciding factors in scar production. In spite of thorough initial care

and closure one is occasionally faced with a displeasing scar when healing is completed. Such cases are all amenable to secondary repair when conditions are more favorable for a satisfactory result.

#### CONCLUSIONS

1. Injuries of the face and jaws should be accorded the benefit of thorough clinical as well as radiographic examination.
2. Reduction and immobilization of fractured jaws have been greatly simplified by the use of intermaxillary rubber band traction.
3. For minimal facial disfigurement, the repair of soft tissue wounds of the face demands thorough and meticulous initial care.

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# CONTUSIONS, CRUSHING INJURIES AND WOUNDS OF THE THORAX\*

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## INTRODUCTION

THE results of trauma to the chest are best understood after appreciation of certain of the functions of the organs involved and of the derangements produced by injuries. The bony thorax constitutes a protective elastic cage which is subject to some variation in size with respiratory movements. This cage is closed inferiorly by the domes of the diaphragm, and at the superior thoracic aperture transmits the trachea and esophagus, as well as the great vessels and nerves, and contains also the extreme apices of the lungs. The fascial planes of the interior of the thorax blend with those of the deep fascia of the neck so that air released into the mediastinum quickly appears at the base of the neck.

Among its other functions connected with respiration the chest wall in its form and movements is partly responsible for the negative pressure in the potential pleural space and its structural integrity is of vital importance in maintaining this pressure.

The diaphragm is protected from the effect of blows by the bony thorax, but its regulatory mechanism is quite sensitive and in association with severe traumata, particularly to the lower ribs, may be paralyzed, with the result that the diaphragm assumes a much higher position than normal, and may even be penetrated in the process of aspiration of the pleural cavity at a usually safe level.

The bony framework of the thoracic cage is very elastic in childhood, but becomes more brittle with age. Hence, particularly in elderly people, fractures may be caused by relatively slight injury.

Any wound of the thorax which enters the pleural cavity, unless it is immediately closed either by falling together of its edges, if it be a small stab or puncture wound, or by suture or by means of airtight dressings if it is large, results in what is known as open pneumothorax. In this condition there is a free communication between the pleural cavity and the outside which causes the intrapleural negative pressure to be replaced by atmospheric pressure. The lung on the involved side is thus partly collapsed and loses for the most part its respiratory function. In addition, unless fixed, the mediastinum is dislocated toward the opposite side with consequent compression of that lung and further decrease in the available respiratory capacity. Other factors such as loss of the aspiratory function of the normally negative intrathoracic pressure on the great veins and the waste effort in respiratory movements in sucking air into the pleural cavity where it cannot be utilized in oxygenating the blood also enter in. It is not to be wondered at, therefore, that open thoracic wounds are of very serious moment and should be closed at once.

## MINOR CONTUSIONS AND NON-PENETRATING WOUNDS OF THE SOFT PARTS

There is little concerning the contusions and non-penetrating wounds of the soft parts, when present alone, which distinguishes them from similar lesions elsewhere in the body. Hematomata of considerable size may develop, but rarely require active treatment. The only point requiring comment is that wounds of the soft parts of the chest wall may be asso-

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ciated with some subcutaneous emphysema of the surrounding tissues due to the respiratory movements even when the thoracic wall is not penetrated or the lung ruptured. While one should always suspect a penetrating wound or rupture of the lung when this sign is present, the absence of pneumothorax and the limited extent of the emphysema usually are of diagnostic significance. All lacerations, if seen within six to eight hours of injury, should be closed after debridement and a firm dressing applied.

#### MAJOR CONTUSIONS AND CRUSHING INJURIES OF THE THORAX

The thorax may be subjected to contusions or crushing injuries as a result of blows, falls, flying debris or in automobile, airplane or railroad accidents. Many of these are similar to the injuries described in the World War, and the major crushing injuries resulting from caving in of trenches or dugouts find their counterparts in the accidents in industrial excavations and in crowds subjected to panic as in fires and other disasters. The less serious injuries give rise to few symptoms other than those of contusions elsewhere and are recovered from promptly. However, even in the minor cases thorough examination is imperative, as occasionally fractured ribs or unsuspected pneumothorax or hemothorax may be discovered. Many are of a severe nature and are quite as apt to lead to serious consequences as the penetrating wounds of the chest.

A classification of these injuries on the basis of clinical and pathologic findings applicable to individual cases is difficult to set up, but they may be divided roughly into three groups: (1) a group in which, following severe injury, there are symptoms of serious intrathoracic damage but in which physical and laboratory examination fails to reveal evidence of actual anatomic change—to this type of case the term "commotio thoracis" has been applied; (2) a group in which the condition known as traumatic asphyxia is present—in this

state, which follows severe compression or crushing injury, the patient presents a remarkable dark bluish discoloration of the face, neck and upper chest; and finally (3) a group, comprising by far the larger number of patients with serious thoracic injury, in which both symptoms and signs of severe intrathoracic damage are evident.

*Commotio Thoracis.* This term refers to a definite clinical entity the exact explanation of which is somewhat obscure and which should only be diagnosed after careful examination has failed to reveal other reasons for the symptoms. It was seen in the war in association with tangential blows from grenades or other flying objects or in men near an exploding shell but who were not actually struck by any of its fragments. In clinical life it may occur in explosions or in other accidents in which the individual is badly shaken up and but narrowly escapes serious injury. It would seem that there may be an added element of tremendous emotional strain at the same time. The symptoms are those of syncope, the patient falling unconscious with cold, pale skin and barely perceptible pulse. The pulse rate is slow and often irregular, the respirations slow and shallow. From this state the patient may recover completely, but in some cases treatment is unavailing and death results. Autopsies were performed on a number of such cases in the last war in which no internal or external injury was found to explain the fatal outcome. This condition has been compared to shock or to cerebral concussion and many authors have stressed the importance of nervous impulses in producing the slow pulse and respirations and the sudden drop in blood pressure.

The diagnosis should only be made after the most careful examinations have failed to reveal definite evidence of either intrathoracic or intracranial injury.

The treatment is supportive, as in shock, combined with the administration of oxygen with 5 to 7 per cent CO<sub>2</sub>. The administration of oxygen with enough CO<sub>2</sub> added to prevent washing out this sub-

stance from the blood stream constitutes one of the most useful measures in the treatment of intrathoracic injuries.

*Traumatic Asphyxia.* This peculiar condition is characterized as the name suggests by a dark blue discoloration of the face, neck, upper chest, and less often of the shoulders and upper arms. It is sometimes seen in patients who have suffered a sudden and relatively brief compression of either or both the thorax and upper abdomen. Most often this force is applied directly, the individual being caught between cars or crushed under some heavy object, but the condition may occur when a person is "doubled up" by a force exerted against the upper part of the back and forcing the abdomen and chest against the knees (jack-knife injury). There is usually no direct injury of the head and neck.

The discoloration is commonly most marked about the lids, lips and nose, and less so about the ears and neck. The bluish background of the discoloration is often studded with minute petechial hemorrhages, and these also appear on the mucosae of the mouth and throat and in the auditory meatus. Commonly, the discoloration is absent at points where something such as a collar-band, suspenders, or even creases of clothing have pressed upon the underlying skin.

By about the fourth day the color begins to fade and gradually disappears, but in doing so leaves behind none of the color changes associated with extravasation of blood except in sites where petechial hemorrhages have been present. This fact indicates that the discoloration is not due to actual extravasation of blood but is associated with marked stasis in the vessels of the skin. This view is supported by the examination of sections of skin removed from discolored areas which failed to reveal any evidence of blood.

In addition to the discoloration, there is commonly present considerable edema of the face, and particularly of the eyes and lips. Subconjunctival hemorrhages are frequently seen and there may be bleeding

from the nose or mouth. Visual disturbances have been reported in about 10 per cent of the cases, some of which have been transient, but in some blindness, associated with progressive optic atrophy, has resulted. This may be explained on the basis of hemorrhage into the retina or degenerative changes secondary to vascular stasis and edema. Unconsciousness of short duration has been noted in about 25 per cent of the cases reported in the literature.

While the appearance of the patient is alarming, in the absence of the complications noted or of severe associated injuries, the condition is not in itself of serious consequence and most of the cases recover completely. However, these patients should be most carefully examined and observed and such supportive measures employed as may be indicated.

In a typical case, a young girl, A. B., age 19, was admitted to the wards of the New York Hospital on March 18, 1939 after an automobile accident. She had been pinned beneath the car in which she was riding, which had overturned following collision with another car. After being extricated, she was brought immediately to the hospital.

On admission, she lay on the examining table in extreme distress. Her temperature was 38.6°C. (rectal), her pulse 122, respirations 22. Blood pressure was not taken on admission. She was struggling violently for breath. Her respirations were heaving and a quantity of frothy, bloody material was sprayed from the nose and mouth. She could not be aroused although from time to time she showed apparently voluntary motions of all the extremities.

There was a very dark purple cyanosis involving the third and fourth interspaces. Over the anterior chest and shoulders the cyanosis had a mottled or irregularly streaked distribution. The face was a dark purple color, the eyes were wide and staring, the jaws clenched, the tongue between the teeth. Scalp and skull showed no bony deformities or lacerations, the pupils reacted equally to light and accommodation, but the fundi could not be visualized at the time. Both nostrils contained blood, but there were no obvious bleeding points or deformities. No bleeding from the ears was

observed, but blood was present in the mouth and pharynx.

The neck was thick and distended anteriorly, its skin cyanotic. The larynx and trachea were not palpable. The chest was symmetrical, with no bony deformities. There was no subcutaneous emphysema. A few coarse râles were heard throughout both lungs, but otherwise they were clear to percussion and auscultation. The heart was not enlarged, maintained regular rhythm, with sounds distant but no murmurs. Pulse was of good quality.

There was a large abrasion over the postero-medial aspect of the right calf, but no deformity or limitation of motion.

Urine examination and the Kline test proved negative. Red blood cells numbered 4,400,000, white cells 24,000. The differential was normal and the hemoglobin 94 per cent. X-rays of spine, chest and right leg showed no evidence of fracture. A diagnosis of fractured larynx with traumatic asphyxia was made. A tracheotomy immediately on admission brought prompt improvement in respirations. Examination of the pelvis showed fractures of the ischium and pubis on the left, with the fragments in good position.

The temperature rose to 39°C., but gradually declined until the fifth day after her admission. There was slight pneumonitis, by x-ray, but no definite pneumonia at this time.

The patient's color gradually improved, the tracheotomy tube was removed on the tenth day after admission. About the sixteenth day after operation her complexion was perfectly normal. From the fourteenth day onward she made a perfectly uneventful recovery. Indirect laryngoscopy on the tenth day following admission showed a minimal amount of swelling in the larynx, but no vocal cord paralysis. The patient's tracheotomy wound healed up promptly and cleanly. She was kept flat in bed for six weeks after admission because of the fractured pelvis. On the thirty-eighth day after admission x-rays of the fractured pelvis showed the fragments to be in good position, with considerable callus formation.

The patient was allowed out of bed on the thirty-ninth day after admission and was discharged on the forty-first day. On discharge her general condition was excellent. Examination of the optic fundi showed no evidence of scars or hemorrhage. Her skin had entirely cleared up.

While in this case there was the complication of fracture of the larynx which required tracheotomy, the initial picture and the course of the traumatic asphyxia were typical.

*Serious Thoracic Injuries.* The third group comprising the greater number includes those cases of serious thoracic injuries. These may be associated not only with extensive injury to the chest wall resulting in massive hematomata in the muscles and subcutaneous tissues and multiple fractures of the ribs, but also may cause serious damage to the intrathoracic viscera including lungs, pleura, pericardium, heart, great vessels, trachea and diaphragm. In contusions of the lower thorax, the spleen, liver, kidneys and gastrointestinal tract may also be injured.

Fractures of the ribs may cause laceration of the pleura which of itself is of little consequence, but when combined with more extensive injuries to the thoracic wall and lung may give rise to widespread subcutaneous emphysema, hemothorax or pneumothorax.

Several types of pulmonary injury may be seen. Thus the lung may be lacerated by a sharp fragment of rib or may be ruptured due to compressing trauma when the glottis is closed. A common pathologic finding in cases of contusion is hemorrhagic consolidation of the lung. Here, due perhaps to rupture of the interalveolar capillaries, the alveoli become filled with blood which is gradually absorbed as the condition clears. While the pulmonary damage is commonly most severe on the side toward the contusion, "contrecoup" injury of the opposite lung may be encountered and may even be more extensive than in the lung nearest the point of impact.

*Wounds of the Thorax.* Wounds of the chest in civil life, while differing somewhat in type and in the frequency of the more minor variety, present many of the same problems as those seen in military surgery. Thus, shotgun wounds of the chest are in many ways similar to the extensive shell wounds seen during the last war, and the

modern high velocity steel jacketed revolver bullets produce wounds quite similar to rifle bullets. Only in those series containing a preponderance of stab wounds from "switch blade" knives or from icepicks do the chest wounds of civil life appear somewhat less serious. Thus in a series reported from the Cincinnati General Hospital in which bullet wounds predominated, the mortality was 39 per cent, a figure quite comparable to those reported from base hospitals in the war. Elkin,<sup>1</sup> on the other hand, reports a series from Atlanta 86 per cent of which were knife or icepick stab wounds, with a 6 per cent mortality.

The immediate mortality obviously depends on the type of wound and the damage to intrathoracic viscera; even in those who survive the initial injury, these factors are of importance. First of all, such wounds may be classified into open and closed varieties. In the former there is a sufficiently large opening into the pleural cavity to permit the ingress of air and the development of open pneumothorax. Such wounds are of extreme gravity and should be closed at once. In others the wound is small or of such character that its edges fall together and the amount of air entering the pleura is minimal. In the absence of complications these wounds are of little consequence.

*Symptoms.* All patients with serious thoracic injuries are in shock when first seen and this may mask the specific symptoms of intrathoracic damage. As recovery from shock occurs, however, pain, difficult respiration, oppression in the chest, and cough, often with bloody sputum, appear and the cyanosis associated with the shock continues. Rapidly spreading subcutaneous emphysema may be encountered. The respirations are of a peculiar grunting or gasping type and the patient is in great distress. In any extensive injury to the ribs the abdominal muscles, particularly of the involved side, are splinted.

*Treatment of Chest Injuries.* In most instances patients with major chest injuries are in shock when first seen and it is this

condition which requires immediate treatment. Heat and morphia, in the absence of associated head injury, to alleviate pain and distress are most useful, and intravenous infusion or transfusion may be required. The patient's position must be adapted to his comfort since individuals with serious chest injuries often do not tolerate well a prone or head down position. The administration of oxygen through an intranasal catheter or by means of an oxygen tent when available is important in relieving respiratory distress. Open chest wounds are to be closed either temporarily by means of dressings, or, better, by suture at the earliest possible moment.

With the exception of these measures, the treatment of chest injuries is largely concerned with the effects of damage to intrathoracic organs. Certain of these may require immediate attention, while in others treatment may be delayed.

The three conditions requiring most urgent emergency treatment are tension pneumothorax, rapidly accumulating hemothorax and multiple section fractures of the ribs with loss of rigidity of a portion of the chest wall, the so-called "stove-in-chest."

Tension pneumothorax is a form of closed pneumothorax resulting from a laceration or rupture of the lung of such a character that it exerts a valve-like action on the ingress and egress of air from the lung into the pleural cavity. Under such circumstances the increasingly forceful respirations of the patient serve only to draw more air into the pleura with consequent increase in the intrapleural pressure which may reach an extraordinarily high level. The effects of such pressure with marked dislocation of the mediastinum and compression of the great veins are extremely serious.

On inspection such patients are cyanotic and are making rapid and desperate respiratory efforts which produce a bulging of the tissues at the base of the neck on each expiration. The chest is bulging on the involved side and moves but little with

respiration. The veins of the neck and shoulders are prominent. Percussion yields a high pitched drum-like tympanitic note on the side of the pneumothorax and demonstrates the marked dislocation of the mediastinal structures. The pulse rate is rapid and unless the patient is in shock, is forceful in the early stages, decreasing in volume as the pressure on the great veins interferes with the return of blood to the right heart.

The treatment is immediate aspiration of the pleural cavity at a high point, with the removal of sufficient air to bring the intrapleural pressure to zero. In some cases the pressure in the pleural cavity is so elevated as to blow the plunger forcibly out of an aspirating syringe. The intrapleural pressure having been sufficiently reduced, some idea of the amount of air escaping from the lung can be obtained by connecting the needle to a pneumothorax apparatus in reverse and measuring the rate of accumulation of air. If the air continues to accumulate in the pleural cavity at a rapid rate, it is necessary to insert a small tube through an intercostal stab wound, placing its lower end barely under the surface of water in a bottle beneath the bed, thereby preventing the pressure in the pleura from rising above atmospheric pressure. The tube should be left in until air no longer escapes, which is usually the case in three or four days.

These cases require very prompt diagnosis and treatment, but few, if any, results in surgery are more spectacular than the relief afforded such patients by the reduction of intrapleural pressure. Pneumothorax of lesser grade is best treated expectantly since if the air is entering the pleura from a wound in the lung, collapse of this organ may be an important aid to healing and the air will be gradually absorbed.

Hemothorax may occur with contusions, crushing injuries, or wounds of the chest from injury to a vessel in the chest wall such as an intercostal or internal mammary artery, or to a pulmonary vessel or to both.

Because the pressure in the vessels of the lung is only 40 mm. of Hg. at most, the accumulation of blood following injury to the lung is much less rapid than is the case when an intercostal artery is the source of the hemorrhage. Moreover, when the lung is torn the bleeding tends to cease as the lung is compressed by the rising level of the blood in the pleural cavity, as well as by the coincident pneumothorax. Bleeding from the internal mammary or from an intercostal vessel, however, may be quite severe and continue longer since the pressure in these vessels is relatively so high. Accumulation of blood in the pleural cavity should be suspected in all thoracic injuries and will be found to be present, to some extent at least, in almost all of those of severe grade, often with associated pneumothorax.

Physical examination yields evidence of fluid, with or without air in the pleural cavity, usually with more or less dislocation of the mediastinum. The latter depends to some extent on the amount of blood present. X-ray is confirmatory and shows a fluid level when air is also present. Aspiration of the chest yields fresh blood which does not clot even on standing.

Treatment of hemothorax should be conservative at first, except in cases of massive accumulations in which there are urgent pressure symptoms, since too early aspiration of any quantity of blood may only result in recurrence of the hemorrhage as the intrapleural pressure is reduced. When, because of urgent symptoms, immediate or early evacuation of some of the blood is imperative, it should be replaced with about an equivalent quantity of air, thereby maintaining some of the pressure but substituting a compressible medium.

After forty-eight hours partial evacuation may be begun, removing about 500 c.c. daily. The blood becomes progressively diluted with a transudate caused by the presence of blood in the pleura. Small quantities will be absorbed but large amounts disappear quite slowly and leave behind deforming adhesions or extensive fibrosis as the



accumulation of fibrin in the costophrenic angle is organized. If there is infection in the hemothorax, it is treated as an empyema, simple drainage usually sufficing, but in gunshot wounds retained foreign bodies such as fragments of clothing may make wider thoracotomy with exploration of the pleural cavity necessary.

Multiple section fracture of the ribs or "stove-in-chest" is a very serious type of injury, particularly in older patients in whom it is most commonly seen. Due to the fact that the supporting rigidity of the ribs is lost, the chest wall moves in during inspiration and out during expiration, and corresponding movement takes place in the mediastinum. Usually the lung of the same side and occasionally the contralateral lung are contused with resulting complications, and since elderly people are most often the victims, the incidence of pneumonia is very high.

The diagnosis of the condition presents little difficulty since the paradoxical movements of the involved area are quite evident. The patients are in great distress both from pain and dyspnea.

The treatment consists in applying a firm dressing over the involved area and strapping the chest on that side. The patient should be placed in an oxygen tent and the injured side supported by pillows or the patient induced to lie on that side if possible.

Subcutaneous emphysema, while a striking finding, is not of serious import unless it be associated with mediastinal emphysema. When the latter is present it is commonly combined with pneumothorax, often under considerable tension, and will disappear when and if the intrapleural pressure is relieved. Other measures include incision in the base of the neck, but this adds the risk of gravitating mediastinitis and is to be avoided if possible. On the whole, subcutaneous emphysema tends to disappear once the source of the air and its access to the subcutaneous tissue is eliminated.

*Injuries to the Heart and Pericardium.* Injuries to the heart and pericardium, as well as to the great vessels, are not so common in connection with contusions and crushing injuries as is the case with penetrating wounds, although, as has been pointed out by Beck, cardiac contusions are probably of much more common occurrence than was formerly believed. Occasionally the pericardium may be torn or ruptured with resulting hemo- or pneumohemopericardium. In the so-called "steering wheel" injury described by Beck<sup>2</sup> in which this structure is forcefully jammed against the lower sternum in collision of automobiles, there may be serious compression of the heart resulting in actual rupture, in fragmentation of the myocardium or in its major contusion. Such patients may subsequently suffer severe attacks or even die from what appears to be coronary occlusion with myocardial infarction, commonly in the second week after the accident.

All cases in which cardiac contusion seems likely should be carefully observed for symptoms and signs suggesting coronary disease, and kept in bed for a period of at least two weeks.

*Gunshot Wounds.* Gunshot wounds of the heart are almost uniformly and quickly fatal, survival being possible only in the extremely rare case in which very slight damage to the cardiac muscle is produced. Somewhat less serious are the simple stab wounds of the heart which receive immediate attention. Such patients may be free from symptoms for a minute or so, only to collapse as the pericardium becomes filled with blood. The diagnosis rests on such a history plus evidence of acute cardiac tamponade. As blood accumulates in the pericardium, diastole is interfered with, the venous pressure rises with engorgement of the superficial veins of the neck and circulatory failure results with feeble or absent pulse and arterial blood pressure too low to measure.

The only possible treatment is operation with relief of the tamponade and suture of

the cardiac wound. This has now been accomplished in a fairly large number of cases. However, only a minute fraction of the patients with cardiac wounds survive long enough to be treated, and even after suture of the wound a high percentage succumb to complications such as pericarditis or pneumonia.

*Combined Thoracic and Abdominal Wounds.* Concomitant injury of abdominal viscera is a serious complication of many thoracic wounds and should always be suspected and ruled out. The seriousness of such wounds depends on the causative agent and the structures involved, but all are dangerous and require urgent treatment. The diagnosis is often difficult and occasionally is only possible after exploration, but in all, the symptoms and signs of intra-abdominal injury are added to those of the chest wound.

Wounds on the right side involving the liver alone give rise to serious hemorrhage, and the leakage of bile into the pleura or peritoneum is a complicating factor. Injury to the liver is so difficult to handle surgically and the danger of diaphragmatic hernia on the right so comparatively small, that such wounds are best treated conservatively at first, reserving operation for the drainage of secondary abscess in the pleura or peritoneum if this supervenes. However, it is often necessary to operate to rule out injury to other organs.

On the left, the picture is quite different and the diagnosis somewhat easier. X-ray may show herniation of the stomach or intestine through the diaphragm, or may demonstrate the presence of gas free in the peritoneal cavity. The latter may cause the liver dulness to be absent on percussion, a very valuable sign of this condition. Stab wounds of the spleen bleed freely, and if this organ is traversed by a bullet the hydraulic force resulting causes it to be shattered to such a degree that at operation it is only a mass of pulp. The kidney may also be shattered by a bullet, and stab wounds of the organ may cause considerable bleeding. Blood evenly sus-

pended in the urine is highly suggestive of kidney injury, and the seepage of urine into the peritoneum or retroperitoneal tissues produces a necrotizing inflammation such as is seen in the subcutaneous tissues following rupture of the urethra.

Combined thoracic and abdominal wounds require operation as soon as the patient's condition will permit, and in most instances the abdominal approach is to be preferred except where intrathoracic exploration is also advisable. Almost all stab wounds can be attacked satisfactorily by laparotomy, and wounds of the diaphragm sutured from below, and, in addition, a more adequate abdominal exploration carried out.

All perforations of the stomach or intestine must be sought out and closed. In wounds of the spleen this organ must be attacked and removed immediately on opening the abdomen, since it may be bleeding vigorously. Renal wounds are dangerous because of hemorrhage and the possibility of extravasation of urine into the tissues. Nephrectomy is indicated if the organ be seriously damaged, but sometimes the insertion of drains through a stab wound in the flank is sufficient. With this exception, all operative wounds should be closed completely, preferably with through-and-through sutures of silver wire to prevent subsequent evisceration.

#### SUMMARY AND GENERAL COMMENT

Except for the minor contusions of the chest and simple fractures of the ribs, all thoracic injuries may have serious consequences and should be assumed to be associated with intrathoracic damage until this is ruled out. In crushing injuries and wounds of the chest, damage to both thoracic and abdominal viscera is occasionally seen and must be carefully sought for, but in many instances of contusions or crushing injuries abdominal symptoms present soon after injury tend to clear up, as they are often of the referred type. All open wounds entering the pleural cavities are to be closed at once.

Almost all patients with serious chest injuries are in shock when first seen and this is the first condition to be treated. Heat and morphia, in the absence of associated head injury, are most important measures. The patient's position must be accommodated to his comfort and circulation since elevation of the foot of the bed or stretcher may increase respiratory distress. The administration of oxygen mixed with a small percentage of  $\text{CO}_2$  is required in most cases and is perhaps the most important single measure in the treatment of thoracic injuries. It affords considerable comfort to the patient and is of great aid in relieving the strain on the cardio-respiratory mechanism. The gas may be administered either by means of a catheter introduced through the nose to the posterior pharynx or, preferably, by means of an oxygen tent. Transfusion of blood or infusion of normal saline and glucose may be indicated. A firm dressing should be

applied in all cases of fractured ribs or loss of stability of the chest wall.

Accurate diagnosis of the type and extent of any intrathoracic damage should be made as soon as possible. Aspiration of air or of blood accumulating in the chest may be necessary. In the case of pneumothorax the needle should be inserted at a point high in the chest, while blood should be aspirated through the seventh or eighth interspaces in the posterior axillary line.

Hemoptysis tends to disappear and subcutaneous emphysema is absorbed once its source is cut off. Pulmonary lesions such as collapse or pneumonia require specific measures, but acute hemorrhagic infiltration usually clears spontaneously.

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# EMERGENCY SURGERY OF THE HEART\*

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## GENERAL CONSIDERATIONS

THE heart, like other thoracic viscera, works under a narrow margin of safety. Rapid changes in pressure relationships, particularly in the pericardium, affect the filling and emptying of the heart, and, if unrelieved, will quickly bring about a standstill of the cardiac mechanism.

Normally the intrapericardial pressure is less than that of the atmosphere, and the pressure in the intrathoracic portions of the venae cavae is probably negative. With the rapid accumulation of fluid in the pericardium, as from pus or blood, the venous pressure rises, and after it reaches a height sufficient to overcome the increased intrapericardial resistance, blood enters the heart, and the circulation continues. Thus, an increasing intrapericardial pressure must be overcome by an ever increasing venous pressure if the circulation is to be maintained. Normally the venous pressure ranges between 75 and 120 mm. of water. In rapidly increasing accumulations of fluid the pericardium cannot distend sufficiently nor can the venous pressure rise to such a level as to allow the filling of the heart for any length of time. However, I have noted a venous pressure as high as 400 mm. of water in acute compression of the heart and have seen this pressure maintained for as long as thirty minutes without a fatal result. Where the tamponade of the heart is gradually produced (serous effusion), the pericardium is slowly distended and a high venous pressure will maintain the circulation for days.

Acute tamponade leads to cerebral anemia, for when the heart can no longer fill, it can no longer empty. Release of tamponade is, therefore, a matter of first

importance, and demands immediate treatment. The symptoms are a low or unobtainable arterial pressure, a high or rising venous pressure, and a quiet heart. The pulse is weak or absent, and the veins, particularly those of the neck, are prominent and strutted. Because of the venous stasis there is a marked pallid cyanosis of the lips and tongue.

Operations of emergency will, therefore, involve those conditions giving rise to acute compression; wounds and suppuration. In addition, the removal of emboli blocking the pulmonary artery and resuscitation of the stopped heart are considered.

## WOUNDS OF THE HEART

Wounds of the heart, though relatively rare, are being reported with increasing frequency but the condition is often overlooked. Early diagnosis is necessary, for delay in operating is rapidly fatal. Every surgeon should realize that at any time the necessity may arise for immediate cardiorrhaphy. He should, therefore, have a definite knowledge of the anatomy and physiology relating to the surgery of this field. In addition he should have in mind a technique of approach and suture applicable to most cases. This technique should be improved by cadaver dissections and operations upon animals.

*Diagnosis.* Wounds of the heart which are amenable to suture are usually produced by a knife or ice pick. Gunshot wounds are more apt to prove fatal before operation can be carried out, but the same principles of diagnosis and the same technique of suture are applicable.

Because of its position in relation to the anterior chest wall, wounds of the right ventricle are more numerous, but wounds

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of all four chambers as well as those of the intrapericardial portions of the great vessels may be encountered. (Fig. 1.) The

rise in intrapericardial pressure, the venae cavae can no longer empty normal quantities of blood to the heart, and cerebral

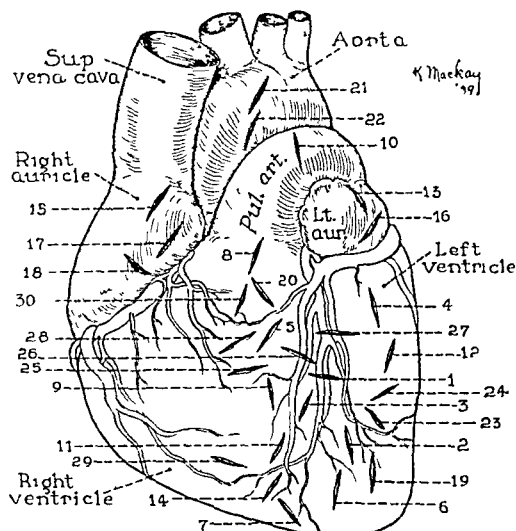


FIG. 1. Approximate location of thirty stab wounds of the heart. There were thirteen of the right ventricle, nine of the left ventricle, five of the auricles, one of the pulmonary artery and two of the aorta.

exact location of the wound can only be surmised before operation, since symptoms from bleeding or tamponade will be the same, regardless of the location. Death may occur from rapid loss of blood either into the chest or to the outside, but death is more likely to occur as a result of tamponade.

The *history* is usually characteristic. There is freedom from symptoms for several minutes after the injury, followed by exhaustion and then loss of consciousness. Either stupor or wild delirium may follow. Patients have been known to walk several blocks or to continue fighting for as long as five minutes after a wound of the heart. Bleeding is profuse at first, but soon stops. This train of symptoms is due to a rapid but gradual tamponade. When the heart is wounded, it bleeds freely to the outside and usually into the pleural cavity as well. At the same time some blood collects in the pericardium and when 100 to 200 c.c. have so collected, the heart is compressed. Contractions become weak, and bleeding to the outside stops. With the

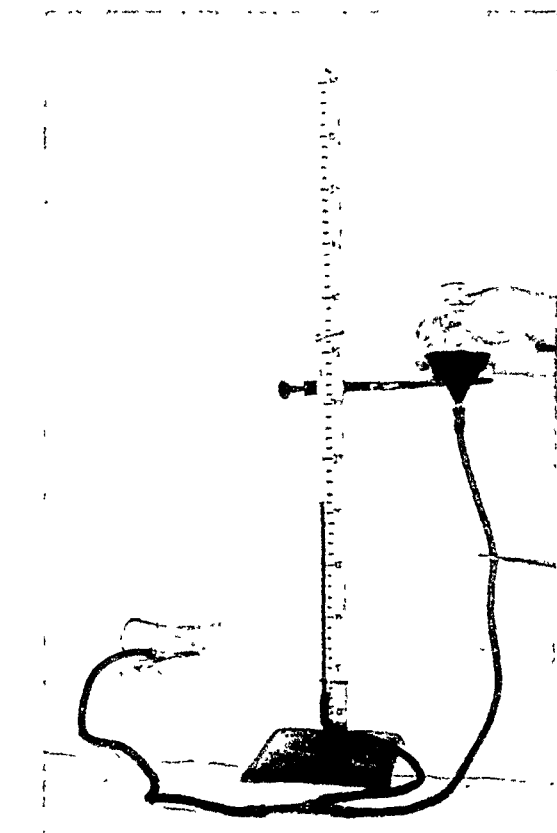


FIG. 2. Estimation of the venous pressure by the direct method. The needle is in the median basilic vein. The fluid has been colored for the purpose of illustration.

anemia, as evidenced by unconsciousness, results.

The position and direction of the wound may aid in diagnosis but the course of a bullet, or even a knife thrust, is notoriously misleading, although those near the left of the sternum from the second to the fifth interspaces are most apt to injure the heart.

The skin is usually cold and moist, and because of the venous congestion there is a pallid cyanosis of the lips and tongue. The heart sounds are weak, often irregular, and the pulse is weak or imperceptible.

The arterial pressure is lowered, even unobtainable, and the venous pressure is raised as evidenced by prominent strutted veins, particularly those of the neck. By

direct measurement this pressure is frequently above 200 mm. of water, and a rise to 400 mm. of water has been observed. Such a pressure is consistent with life if not

wound, followed by rapid collapse and unconsciousness.

2. Heart sounds are weak, as is the pulse.

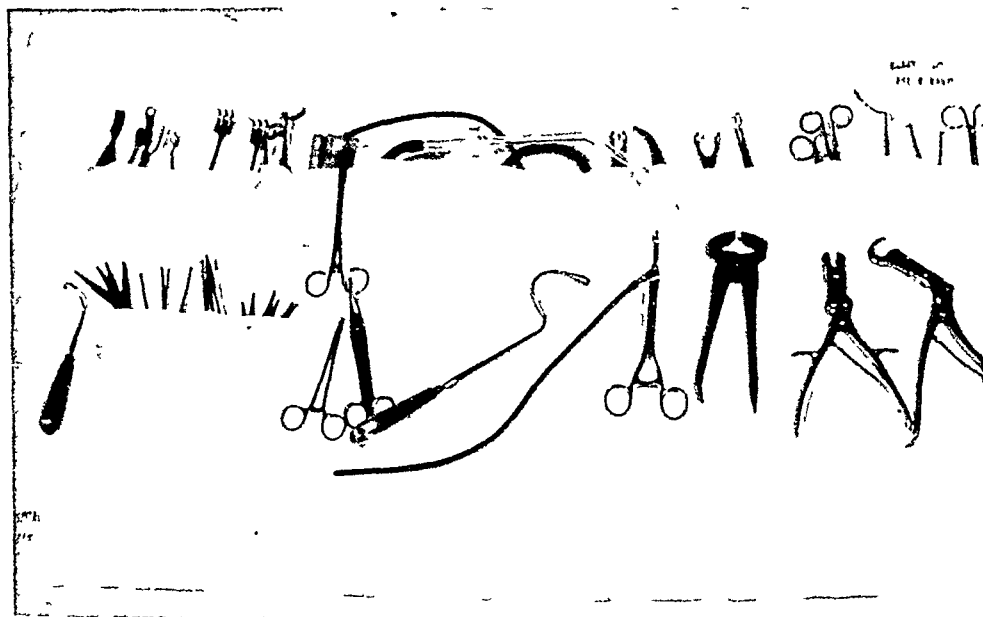


FIG. 3. Instruments are sterilized and kept in a special container for immediate use.

maintained for too long a period. Venous pressure readings should be done by the direct method by inserting a needle into a basilic vein and noting on an attached manometer the height at which a column of physiologic salt solution is maintained. (Fig. 2.) The patient's body should be horizontal, and the vein should be on a level with the heart.

Roentgenograms are of no value, since death may occur from an amount of blood in the pericardial sac too small to cause a noticeable change in the size and contour of the heart shadow. *Fluoroscopic examination is of great value*, since the normal pulsations are prevented by a small accumulation of blood in the pericardial sac. Of all the diagnostic aids, this is the most accurate in proving or disproving one's suspicions of cardiac tamponade. It had best be done with the portable fluoroscope, for with this unit the patient need only be turned on his side for the examination.

To summarize:

1. There is usually a history of freedom from symptoms for several minutes after a

3. The arterial pressure is lowered.

4. The venous pressure is raised.

5. Fluoroscopic examination shows a quiet heart.

*Operation* should be carried out as soon as the diagnosis is established. To hasten and facilitate this, all necessary instruments should be kept ready in a separate container and sterilized by autoclave. (Fig. 3.) Since infection of the pericardium and pleura is a frequent complication, the operation should be carried out with meticulous care. While preparations are being made, sufficient morphine should be given to insure rest and quiet. The head should be lowered and the body kept warm. Theoretically, intravenous infusions are of little value so long as tamponade is present, but where excessive hemorrhage has occurred, it is indicated. The administration of a 6 per cent solution of acacia may be life saving, and autotransfusion of citrated blood removed during the operation should be given when possible. Blood transfusion should be done as soon as possible after the release of the tamponade.

*Anesthesia.* Inhalation anesthesia is preferable to local anesthesia for several reasons. The pleura may have been opened

of the sternum, the approach to the heart should always be made to the left of the sternum, and the incision should be so

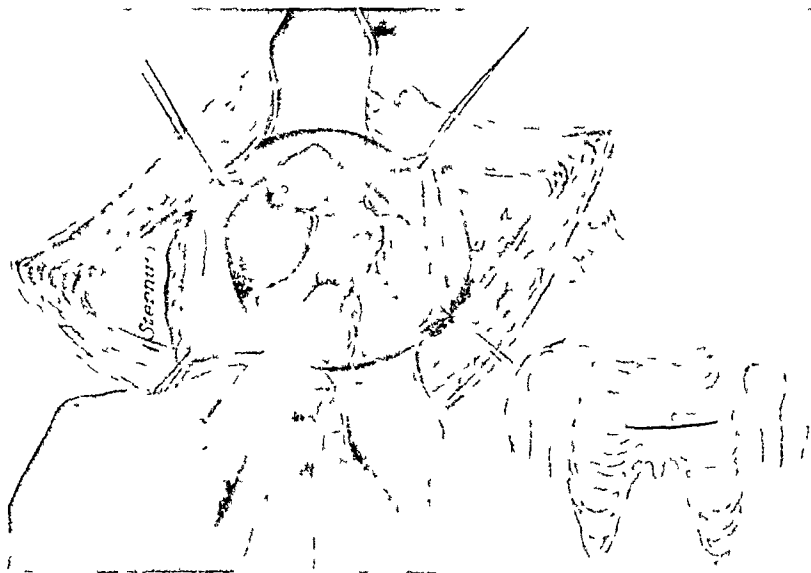


FIG. 4. Suture of a heart wound. The heart has been exposed by removal of the fourth costal cartilage and a portion of the sternum. The suture is passed through the wound beneath the finger which temporarily occludes the opening.

by the wound, or may be accidentally opened during the operation, and nitrous oxide and oxygen under positive pressure is necessary for the inflation of the lung. The difficulties of heart suture require that the patient be quiet, but these patients are usually widely excited or are apt to become so with release of the tamponade. Unless completely anesthetized their struggles may interfere with the operation at the most inopportune time.

*Suture of the Heart.* The incision should be so planned as to give the best exposure with the least trauma. It must also be made with some consideration as to the position of the external wound. Although the pleura is usually injured when the heart is wounded, further tearing of this membrane should be avoided if possible, for it adds greatly to the shock of the patient. For that reason dissection of the pleura from the pericardium is best begun in the fourth or fifth interspace because of its usual reflection to the left at that point. Unless the skin wound is well to the right

planned that it can readily be enlarged if the heart wound is not easily located.

With these factors in mind, experience has shown that a long transverse incision extending well across the sternum gives the best exposure. (Fig. 4.) By this approach one or two ribs can be removed, and, if necessary, the adjacent costal cartilages cut and a portion of the sternum removed. The pectoralis major muscle is separated in the direction of its fibers and can easily be retracted from the surface of three ribs. One or two ribs with their costal cartilages are then removed. Dissection should begin well out on the rib which can be easily lifted from its periosteal bed and cut without injuring the pleura. By lifting the rib the cartilage can then be removed with less danger of injury to the pleura than if the cartilaginous portion is removed first. The internal mammary vessels are ligated and cut, the triangularis muscle is divided and the pleura displaced outward by careful gauze and finger dissection.

A second incision, and one giving excellent exposure, consists of turning a musculocutaneous flap laterally and removing

of a suture directly under the finger. This is left untied for the moment and is held in the left hand for traction and hemostasis

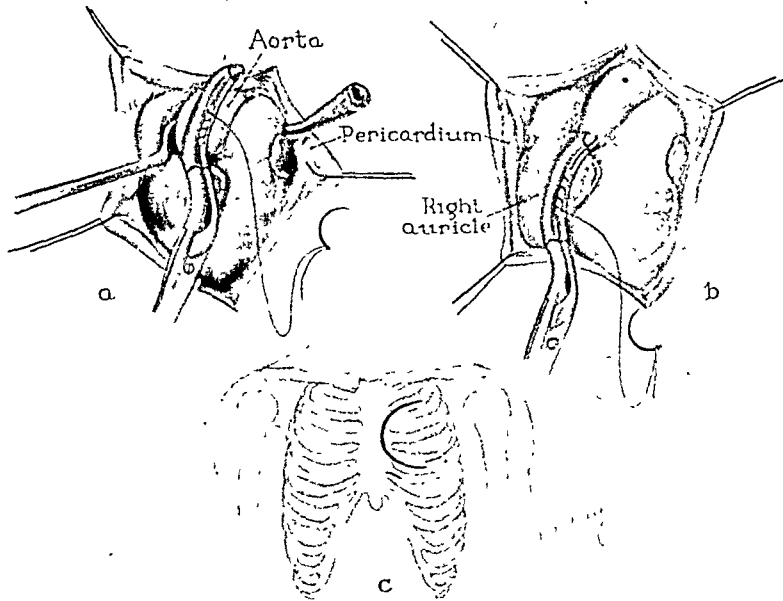


FIG. 5. Methods of suturing the great vessels and auricles. *a*, Trendelenburg probe has been passed through the sinus behind the aorta and pulmonary artery in order to bring the vessels into better view and partially to constrict bleeding. Trendelenburg clamp is shown applied to a wound in the aorta to facilitate suturing. *b*, Trendelenburg clamp applied to a wound of the auricle. *c*, a second incision for approach to the heart.

two or more costal cartilages and ribs. (Fig. 5.) It requires more time to open and close the chest wall and is more likely to induce shock.

The pericardium will be tense, bulging and blue, and its pulsations will be weak and imperceptible. If the wound in the pericardium is seen, it should be enlarged, or, if not readily found, it is opened between stay sutures of silk. Occasionally the heart wound can be located before the blood and clots are removed before the heart starts bleeding profusely. If it is not immediately seen, the blood and clots are removed by suction. When the intrapericardial pressure is relieved, the bleeding becomes marked, as the contractions of the heart increase in force. When the wound is located, and it is most often found in the right ventricle, its closure is facilitated by placing the index finger of the left hand over it. In this way the bleeding will be impeded sufficiently to allow the passage

while other sutures are placed and tied. They should pass well into the substance of the muscle, but not into the chamber of the heart. Fine black silk on curved calyx-eye needles is the material of choice. Heart muscle is extremely friable, and for this reason, the *finger should not be placed in the wound*, and sutures should be tied with only enough tension to approximate the edges. (Fig. 4.)

Injuries to the coronary vessels may require ligature, but are not necessarily fatal, unless the patient is old or the vessels are already the seat of sclerosis.

Wounds of an auricle, or the right ventricle behind the sternum, or in the lateral or posterior portion of the left ventricle, are difficult to close because of their position. Here the placing of a stay suture through the apex, as advocated by Ballance and by Beck, is of value in rotating the heart into a position where sutures can be placed.



Hemorrhage from a wound of the intrapericardial portions of the great vessels may be checked by passing the Trendelenburg probe behind them and impeding the flow of blood until sutures can be placed. (Fig. 5.)

In the wound of an auricle, the Trendelenburg clamp may be applied to check the flow of blood until sutures are placed. (Fig. 5.)

During the course of the operation, the heart may fibrillate, or even stop beating, especially when traction is applied. Should this occur, the operation should be momentarily stopped until normal contractions are resumed. If contractions cease or become weak, 1 c.c. of 1:1000 solution of adrenalin should be injected directly into the heart muscle. Gentle massage by pressure between the index finger and the thumb will often restore the heart beat.

After suture and control of the hemorrhage the pericardium is cleansed by suction and flushing with salt solution. The pericardium is loosely closed with interrupted sutures of silk, leaving sufficient space between the sutures for the escape of any fluid which may accumulate. Occasionally the heart dilates to such an extent that complete closure of the pericardium is impossible. The muscle, fascia, and skin are then closed without drainage.

After operation the patient should be placed in an oxygen tent. Fowler's position will usually facilitate breathing. Morphine should be given in sufficient amounts to insure quiet and rest.

Since the pleura and lung are often injured at the time of the heart injury, hemopneumothorax is frequently present. If its extent is such as to cause embarrassment of respiration, aspiration of the chest should be done, but in the absence of symptoms it is better to allow absorption of the air and blood.

*Immediate prognosis* depends largely upon the interval between injury and operation. Delay may cause death from hemorrhage or tamponade or both. It likewise depends upon the character and

extent of the injury; a bullet usually causes two wounds of the wall or septum with greater hemorrhage and loss of tissue. The location of the wound is of prognostic importance; about 80 per cent with wounds of the right ventricle recover. This is probably because the approach to this chamber and its suture is easier. Wounds of the auricles and the great vessels are more hazardous because of the difficulty of approach and suture of these thin-walled structures.

The *postoperative prognosis* is dependent upon infection. Pneumonia and purulent pericarditis are the cause of death in 75 per cent of the operative cases ending fatally. While pericardial adhesions undoubtedly form after these injuries, they are not of such a character as to produce symptoms either by constriction or by increasing the work of the heart.

#### SUPPURATIVE PERICARDITIS

This condition is frequently overlooked because it is usually a complication of infection elsewhere, and its symptoms are overshadowed by the primary disease. It is to be looked for as a complication of rheumatic heart disease, pneumonia, empyema of the pleura, osteomyelitis, and septicemia. It may follow trauma, as a penetrating wound or contusion. The continuance of a septic course after pneumonia or empyema should make one suspicious of its presence.

The organisms most frequently found are the pneumococcus, streptococcus and staphylococcus. General symptoms are the same as those of infection elsewhere; fever, usually picket-fence, chills, leucocytosis, sweating, anorexia, and rapid wasting. The pulse is rapid, usually paradoxical. There may be pericardial or substernal pain, dysphagia, and difficult breathing. The neck veins are distended and there is a pallid cyanosis. Cardiac tamponade is evidenced by a weak pulse, distant heart sounds, a high venous and a low arterial pressure.

The area of cardiac dulness is increased, and at some time in the course of the

disease a friction rub may be noted. Frequently the liver can be felt. The roentgenogram is of great value in accurately

The pericardium may be approached for drainage by a number of methods. The incision usually employed is the hockey

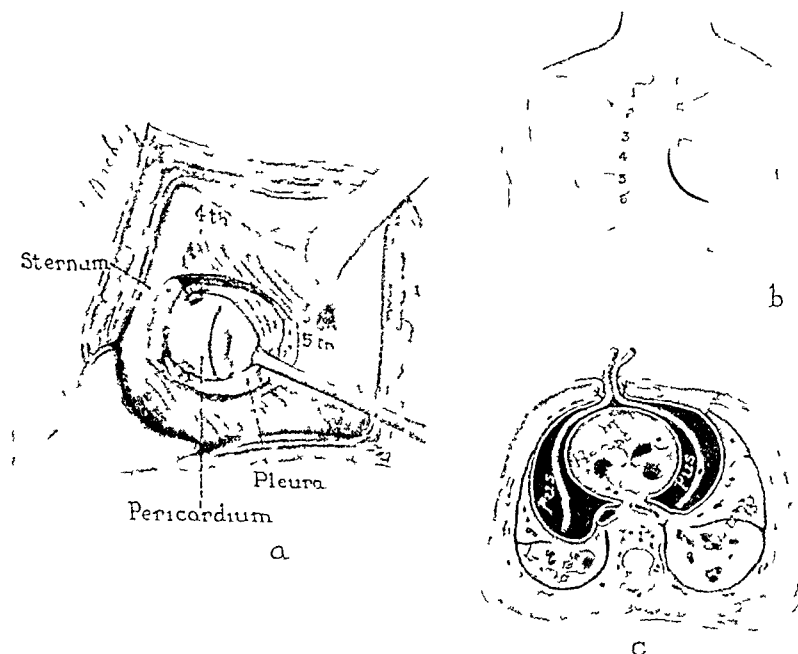


FIG. 6. Drainage of purulent pericarditis. *a*, pericardium exposed by removal of the fifth costal cartilage and a portion of the sternum. *b*, the incision. *c*, cross section showing the position of the drains and the stitching of the pericardium to the subcutaneous tissues.

determining the size and contour of the pericardial shadow, and fluoroscopic examination will show a decrease or even absence in the cardiac pulsation.

Certain diagnosis can only be ascertained by puncture but this is an extremely dangerous procedure. Numerous cases of injury to the heart or coronary vessels with subsequent bleeding have been reported and infection may follow the course of the needle into the pleura or lung. If it is done, the safest place is at the left costoxiphoid angle, directing the needle upward and backward. By this approach the pleura is not entered and the needle reaches the lower and posterior part of the distended pericardial sac. Even with the pericardium distended with fluid the heart assumes an anterior position and pus located posteriorly and laterally may be missed if the puncture is carried out anteriorly. On the whole it is safer to expose the pericardium by operation.

stick one (Fig. 6) along the left lower edge of the sternum and extending out over the fifth and sixth costal cartilages. After the deep structures have been incised and retracted, about 2 inches of the fifth cartilage is removed and the wound further enlarged by removal of a portion of the sternum. The internal mammary vessels are ligated and cut. The triangularis sterni muscle is incised and the edge of the pleura, which can be seen overlapping the pericardium, is carefully pushed back to the left. Should the pleura be accidentally opened, the operation should be delayed and the wound packed for forty-eight hours in order to allow adhesions to close the pleural opening. The pericardium is best opened between stay sutures of fine silk. There may be fine adhesions about the heart which should be separated gently with the finger. A small catheter can be passed to each side of the heart and behind it for irrigation with saline solution.

(Fig. 6.) The edges of the pericardium are sewed to the skin or subcutaneous tissues to prevent too rapid closure, and the catheters, which are left for drainage, need not remain in place more than two or three days. Frequent changing of position will facilitate drainage, particularly if the patient lies on the abdomen several times a day.

Early operation is imperative and should be carried out even before fluid becomes thick. It is, therefore, classed as an emergency operation because the rapid accumulation of pus will produce cardiac tamponade, and death may result from this condition as well as from a generalized infection.

Without operation practically all patients die. With drainage the mortality is about 50 per cent, depending largely upon the nature of the primary infection. If it follows pneumonia or empyema or trauma, the prognosis is good, but if it is but a part of pyemia, the result is usually fatal.

#### PULMONARY EMBOLUS

There is nothing which produces such a feeling of helplessness on the part of the surgeon as a pulmonary embolus. It frequently comes without warning in a patient believed to be recovering, and the result is usually fatal. In half the cases death takes place within five minutes but others may survive for several hours. It is to be looked for where large veins have been ligated, as in hysterectomy, or where phlebitis follows operation.

Effort should, therefore, be directed towards its prevention. This will depend upon the elimination of the causes of thrombosis; the careful handling of tissues, particularly the ligation of vessels, the stimulation of the circulation, and the prevention of slowing of the blood stream. This latter is best accomplished by early active motion of the patient, and the frequent changing of the patient's position and the raising and lowering of the head and foot of the bed. Where Fowler's position is indicated, the legs should be lowered

several times daily to prevent constriction of the venous flow at Poupart's ligaments. The use of tight adhesive and binders, particularly in the upper abdomen, constricts respiration and hinders the return flow to the heart. Binders should be loose and deep breathing encouraged.

Pulmonary emboli account for about 6 per cent of all deaths following operation, and surgical attempts to remove them should always be considered. Since it is "difficult to fix indications for operation" (Nyström), and many apparently hopeless cases spontaneously recover, the question arises whether the dangers of the operation justify its performance.

Trendelenburg described the symptoms of pulmonary embolism as "sudden collapse, pallor, lividity of the lips, loss of pulse, together with deep and distressed respiration." It is usually accompanied by vomiting, a sense of constriction in the chest and the fear of impending death. Since these symptoms and signs are similar to those of coronary occlusion, every effort should be made to differentiate between these conditions. If conditions are suitable for operation and the operating team has been trained for its performance, the patient should be immediately moved into the operating room and prepared for operation.

Trendelenburg's original procedure was carried out through a T-shaped incision through which a portion of the second rib and cartilage was removed. He purposely opened the pleura and exposed the pericardium. The pericardium is opened and a catheter is passed through the great sinus by a special instrument and with this the aorta and pulmonary arteries can be constricted. (Fig. 7.) The artery, which lies anterior to the aorta, is then opened for a distance of 2 cm. and clots removed by forceps and suction. It must be remembered that the left pulmonary artery passes directly to the left, whereas the right is directed posteriorly. After removal of the clots, the opening is held together by a curved clamp and the wound sutured with

continuous silk and reinforced with interrupted sutures of the same material.

If the heart has stopped beating, it

This operation has now been performed over thirty times and about one-third of the patients have survived the operation.

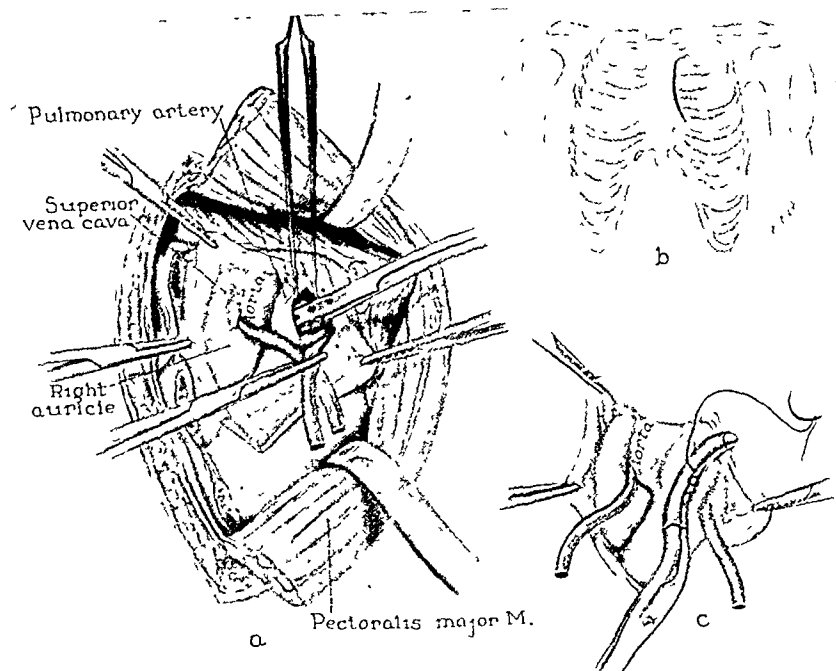


FIG. 7 Removal of an embolus from the pulmonary artery. *a*, the aorta and pulmonary artery are temporarily occluded by a rubber band. The pulmonary artery is held open by a specially devised clamp and the embolus is removed with forceps followed by suction. *b*, the incision. *c*, the wound is occluded with a clamp and closed with a continuous suture of silk.

should be gently massaged at the apex between the thumb and first two fingers and 1 c.c. of 1:1000 solution of adrenalin should be injected into the heart muscle.

The wound in the pulmonary artery is closed, the pericardium is approximated with interrupted sutures of silk and the wound closed in layers with sutures of the same material. Nyström has modified this method and has pointed out that an opening in the pleura is to be carefully avoided since it adds greatly to the shock of the operation. He opens the chest through a longitudinal incision at the left of the sternum (Fig. 7) and resects a portion of the second, third and fourth ribs with their cartilages. The pleura, which is seen overlapping the pericardium at the fourth rib, is then carefully pushed aside and the pericardium opened high up over the great vessels. As in other operations upon the heart, the patient should be immediately placed in an oxygen tent.

Trendelenburg pointed out that the constriction of the vessels should not exceed forty-five seconds. Nyström and Blalock have found that this may be increased to two minutes if only the pulmonary artery is constricted. During the course of the operation it may be necessary frequently to release temporarily the constriction of this vessel.

#### RESUSCITATION OF THE HEART

Sudden heart failure is a specter which constantly confronts the surgeon, for although it rarely occurs, in the majority of instances resuscitation is impossible. The attributable causes are many and varied. Chief among these are mechanical disturbances to the heart itself during operations upon that organ and the pericardium. As already mentioned, traction or pressure may cause fibrillation or arrest, and is a signal for temporary abandonment of the procedure until normal rhythm is

established. Any operation within the chest, such as a lobectomy, the removal of a mediastinal tumor, or even the aspiration

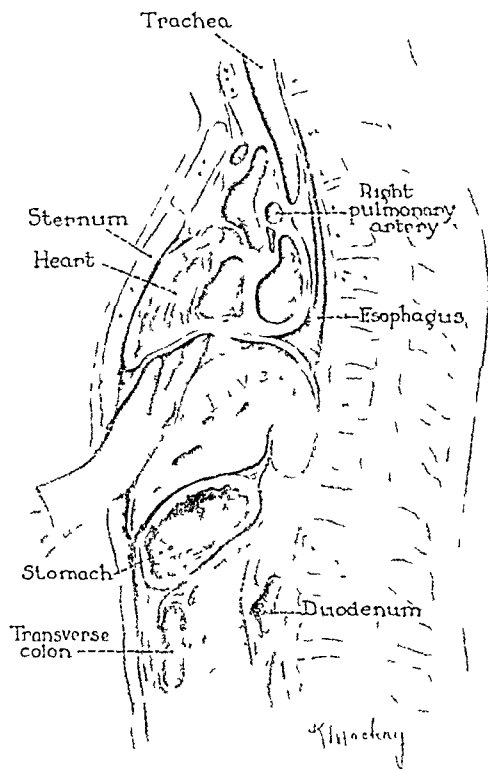


FIG. 8. Massage of the heart through the abdomen. Incision has been made in the epigastrium and the right hand is passed over the liver to the under surface of the diaphragm.

of the pleural cavity, may bring about cardiac standstill.

Of more practical importance is the occurrence of circulatory collapse during the performance of an operation outside the chest. While the exact cause is unknown, it follows deep anesthetic narcosis, hemorrhage, shock, and "status lymphaticus." Often the heart stops without warning at the beginning of an operation—at the time of the skin incision—and this is therefore considered the result of a nervous reflex.

Whatever the cause, attempts have long been made at resuscitation, although progress has been impeded by inability to reproduce the condition experimentally except by narcosis or operations upon the heart. At the time when chloroform was

generally used, cases were numerous and resuscitation experiments were begun. Chief and earliest among these were those of the American surgeon Watson (1887) who, in a series of sixty experiments on dogs, showed that resuscitation was possible either by massage or by needle puncture. Since then numerous attempts to revive the stopped heart have been made in man. The number of permanent recoveries is small, probably less than 25 per cent, and there is no accurate statistical evidence to show that any one method is superior to any other.

The physiologic basis for resuscitation attempts is well summarized by Hyman (1930): "The success of the intracardiac injection procedure . . . is apparently due more to the effect of the puncture wound made in the wall of the heart than to the chemical substance injected. The myocardium of the normal asystolic heart rapidly becomes irritable with the onset of anoxemia. Under these conditions, any mechanical stimulation may irritate the heart to automatic contraction, and the success of massage and percussion of the heart for resuscitation can be explained on this basis. The puncture wound made by the injecting needle becomes a focus of increased irritability, from which a stimulus for myocardial contraction may be developed. The first contractions of the heart after injection are always extrasystoles. The initial extrasystolic arrhythmia may give way quickly to a normal sinus rhythm with prompt recovery on the part of the patient. However, when the period of anoxemia has been so prolonged or so intense that there is considerable disturbance in the electrodynamic factors controlling myocardial contraction, the initial extrasystolic arrhythmia may persist and may be quickly followed by a rapid sequence of ectopic beats. Such a condition leads to pathological fatigue of the ventricles, which may be followed by ventricular fibrillation. Ventricular fibrillation is an extremely hazardous disturbance of the heart and is usually accompanied by immediate collapse of the circulation and death of the patient. This phenomenon explains

the secondary collapse of the circulation often seen following what has apparently been a successful resuscitation of an asystolic heart."

The resuscitation methods generally employed are (1) needle puncture, (2) cardiac injection, (3) cardiac massage, or (4) a combination of these.

Puncture or injection is usually done in the right ventricle, the needle being passed directly backward in the fourth or fifth interspace close to the left side of the sternum. When the resistance of the heart is felt at a depth of 4 to 5 cm. the needle is then thrust into the heart wall. If a contraction occurs at this time it will be easily noted by the movement of the needle.

Many substances have been advocated for injection, including strophanthin, camphor, digifolin, caffeine, and adrenalin. The latter, 1 c.c. of a 1:1000 solution, is the drug most frequently used.

Hyman advocates puncture of the right auricle, on the basis that the auricles are more sensitive to stimulation and that normal ventricular contractions follow the auricular extrasystoles initiated by the puncture. For this a curved needle is passed through the third interspace close to the right border of the sternum. "The needle is directed toward the midline, so that the curve carries the point under the sternum."

The heart is reached for massage by one of three routes: (1) directly through the chest wall; (2) by abdominal incision; and (3) by incision through the diaphragm from below.

Exposure of the heart by opening the chest is too hazardous and time-consuming, and such a procedure would interfere with the giving of artificial respiration. Massage through the abdomen without opening the diaphragm is the method generally employed, particularly if indicated during an abdominal operation. If the abdomen is not already opened, incision is made in the midline of the epigastrium and the right hand passed below the relaxed diaphragm and just over the liver. (Fig. 8.) Pressure is then made on the heart twenty or thirty times a minute.

By the same abdominal approach the diaphragm may be incised for direct massage, but this operation is difficult and productive of shock. It must be remembered that cessation of the heart beat is usually accompanied by respiratory failure, and *artificial respiration must be carried out at the same time.*

Success will largely depend upon the interval between cessation of the heart beat and the beginning of stimulation, whether by injection or massage. Cerebral anemia results about sixty seconds after the heart stops, but some degree of circulation may be present for a considerable time after examination indicates that the heart has stopped. Therefore, it should always be carried out and continued so long as there is any hope of resuscitation.

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# THE TRAUMATIC ABDOMEN

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THE injured abdomen deserves consideration as a clinical entity. It is not so treated in systematic works on surgery, which discuss abdominal injuries not in a single chapter, but in chapters devoted to the abdominal wall and the various viscera. This is inconvenient to the reader, and gives him inadequate information on the causative mechanisms, symptoms and treatment. The excuse for this paper is to call attention to these general features of the subject, which is too vast for detailed treatment in a short article.

For ease of discussion, injuries of the abdomen may be divided into two classes, according to whether they do or do not have external signs of trauma. The second of these is now as common as the first because of the frequency of automobile accidents.

## I. INJURIES WITH EXTERNAL SIGNS OF TRAUMA

Those capable of cure are practically limited to gunshot and stab wounds. The treatment of these is a trite subject, but it may not be amiss to emphasize certain facts about it.

1. The immediate fate of the patient depends almost entirely on whether or not a major blood vessel is severed. If this happens he will die before operation is possible; if not, he can probably endure whatever operation is necessary. In a rather extensive experience with these injuries, the writer has never had a death on the table.

2. It is almost certain that a bullet that has traversed any part of the peritoneal cavity in any direction will have pierced the gastrointestinal tract. The only exception is that of an anteroposterior trajectory

across the top of the subdiaphragmatic space on the right side.

In twenty cases there was only one in which the bullet had not penetrated the stomach or intestine. In this a small caliber bullet entered the left side of the chest, pierced the diaphragm, and then, its force apparently spent, fell to the bottom of the pelvis.

In case the wound of entry is on the chest, buttocks, perineum or even the thigh, the possibility that the bullet has entered the peritoneal cavity must be kept in mind and not dismissed until excluded by x-ray examination. In a case in which the wound of entry was to the left of the perineum, the bullet was located just below the promontory of the sacrum in the mid-line. At laparotomy it was found to have traversed the bladder and the sigmoid. The wounds of the sigmoid were closed as was the posterior wound in the bladder. The patient made an uneventful recovery.

3. Since the surgeon is confronted by an injury which without immediate operation will almost certainly be fatal, he should perform laparotomy as soon as possible without too much concern over the general condition of the patient. This does not mean that necessary preoperative study and preparation should be omitted. It is essential that a careful physical examination be made and that the course of the bullet be determined either by means of wounds of entry and exit, if the latter is present, or by an x-ray study if it is not. A catheterized specimen of urine should be examined and preparation should be made for blood transfusion in the course of the operation. The incision should give ready access to the course of the bullet. The surgeon should proceed systematically

and with deliberation and should not close the abdomen until he has repaired all injuries incompatible with life. This often requires examination of every inch of intestine with perhaps multiple resections thereof, removal of all particulate matter and the arrest of hemorrhage. Bullet wounds of the liver should usually be let alone. Wounds of the pancreas should be closed by suture if they are bleeding. Wounds of the spleen may require its removal if the hemorrhage cannot be controlled by suture. It is unnecessary to make extensive search for a bullet imbedded in the muscles of the back.

Bullet wounds of the kidney require special consideration. They can usually be diagnosed before operation by study of the course of the bullet, by the presence of an effusion of blood in the flank and the usual presence of blood in the urine. If the bullet has entered the peritoneal cavity, it is almost certain to have injured the bowel. It is evident that this injury should be repaired before the injury to the kidney, because otherwise the patient will soon die of peritonitis. After the bowel has been repaired, the opening between the perirenal space and the peritoneal cavity should be closed securely either by suture of the peritoneum or by plugging with omentum. If there is a bullet wound of entry or exit over the kidney, this can be enlarged for tamponade or drainage. It may be convenient to insert this drainage through the wound connecting the abdomen with the perirenal space before closing the abdomen. Unless the bleeding from the kidney is uncontrollable, it is best not to do an immediate nephrectomy.

#### 11. INJURIES WITHOUT EXTERNAL SIGNS OF TRAUMA

These are caused by:

1. Violent compression of the viscera against the spine.
2. A great increase in the intra-abdominal pressure.
3. The forcible introduction of water, air or foreign bodies into the rectum.

The clinician should bear in mind that symptoms which often occur with abdominal injury, as vomiting, ileus and localized pain, may be due to trauma of the chest, spine or extremities.

The most serious injuries within the abdomen may occur without external signs of injury and, in many instances, without, for some time, symptoms of any injury whatsoever. Extensive laceration of the liver or spleen may be unsuspected until the effects of internal hemorrhage are well marked. Rupture of the duodenum or jejunum may not be suspected until hours after the injury which caused it. The same is true of severe injury of the pancreas. Finally, rupture of the diaphragm with passage of various abdominal organs into the chest may not be recognized until after the passage of weeks or months, when an x-ray examination, made because of gastrointestinal symptoms, shows its presence. It behooves us, therefore, to examine carefully every patient who has had any accident which conceivably might cause injury to organs within the abdomen. The following case reports illustrate and enforce this dictum:

A boy, aged 10 years, had been knocked off his bicycle by an automobile, one wheel of which passed over his abdomen above the umbilicus. For a number of hours he had shown no signs of injury, and had been permitted to eat. Operation twenty-four hours after the injury revealed a complete transverse rupture of the second portion of the duodenum.

A boy, 8 years old, was seen one hour after the wheel of a school bus had passed across his abdomen. Except for some marks on the skin the child showed no signs of injury. His abdomen was not distended, his pulse and temperature were normal, he was in no great pain. At laparotomy, performed at once, an almost complete division of the jejunum was found.

From these and other experiences of a similar kind, I conclude that laparotomy should be done immediately on any patient who has suffered a violent compression of the abdomen as from the passage over it of



an automobile wheel, no matter how slight the signs of intra-abdominal injury may be.

Trauma of the kind under consideration may injure the stomach.

A man, aged 30, had several ribs on his left side fractured in an automobile accident. He vomited blood and passed dark blood by rectum. He slowly recovered for two weeks. Then he began to have constant severe pain in the left hypochondrium, and frequent emesis of blood and food. He was admitted five weeks after injury, very anemic, but with negative physical findings except for pain on deep pressure on the left hypochondrium. X-ray examination revealed a large perforated ulcer of the posterior wall of the fundus of the stomach. At operation this finding was confirmed. It is evident that this injury had been caused by compression of the stomach against the spine.

The pancreas may be crushed in the same manner.

The upper part of the abdomen of a farmer was compressed between the upper bar of a hay rack and the beam across the top of a gangway opening of a barn. Clearance between these objects was  $4\frac{1}{2}$  inches. The patient developed an immense collection of fluid in both his greater and lesser peritoneal cavities. The latter was finally drained through the gastrohepatic omentum, and later the necrotic tail of the pancreas was discharged from the wound.

Crushing force, leaving no marks on the abdominal wall, may lacerate the solid viscera or rupture the urinary bladder. A detailed discussion of the diagnosis of these injuries is unnecessary, but the following facts about them should be emphasized:

1. They may give at first no obvious signs of their presence.

2. They can easily be overlooked in a patient having serious injuries in other parts of the body.

3. They can usually be diagnosed if the possibility of their existence is kept in mind.

4. They may be associated with injury to the intestine.

5. Delay in diagnosis may be a far greater peril than exploratory laparotomy.

Increased intra-abdominal pressure is generally admitted to be a rare cause of abdominal injury. Since it compresses the viscera with equal force on all sides, it can damage them only under special conditions. Thus it can rupture a duodenal ulcer having a thin roof attached to a thick ring of scar tissue. The writer observed this in one case. Rupture of the spleen, due solely to increased pressure, has been reported. This must have been caused by compression of the softened organ against the diaphragm.

The most common injury caused by increased intra-abdominal pressure is rupture of the diaphragm. The writer has operated for this injury on six patients in the last two years, and knows of two other cases discovered at autopsy. In all of these the tear in the diaphragm extended outward and slightly backward from the esophageal hiatus. All of the patients were injured in automobile accidents. The tear is evidently caused by sudden great increase in intra-abdominal pressure, due to forward flexion of the body when the diaphragm and muscles of the abdominal wall are strongly contracted. It is, however, often overlooked.

Rupture of the diaphragm is perhaps the only serious abdominal injury which does not require immediate operation. It is not in itself in most cases immediately dangerous to life and it is often associated with injuries in other parts of the body, as concussion of the brain, which render operation dangerous. It is also attended by serious disturbances of intra-thoracic pressure and time should be allowed for the body to adjust itself to these.

*Rupture of the pelvic colon* by compressed air, blood or solid objects introduced into the rectum is frequent enough to be mentioned. The writer has observed the following instances:

1. Perforation of an amebic ulcer of the rectum by the finger.

II. Perforation of the distal sigmoid: (1) By the proctoscope, (2) by a glass tumbler, (3) rupture of the sigmoid, two cases, by enemas. In both of these the enemas had been injected with great force and the site of perforation, as determined by autopsy, was probably a diverticulum. Both patients when first seen had pelvic abscesses, both had had a sudden severe pain when the enemas were injected. Both could probably have been saved by immediate operation.

#### CONSIDERATIONS ON OPERATIVE TECHNIQUE

The repair of these injuries requires their exposure to view, and this sometimes means examination of the entire peritoneal cavity. The operative field is nearly always contaminated. Incisions which give ample exposure and withstand infection are desirable. The writer has found two incisions which meet these requirements.

The first, which is used above the level of the umbilicus, extends from the costal border about 2 inches from the midline, vertically downward to the umbilicus. The structures of the abdominal wall are divided in the line of incision down to the aponeurosis of the transversalis muscle. This is opened in line of its fibers, at any level desired, from the midline to the anterior axillary line. This incision gives excellent exposure of either upper quadrant of the abdomen. It can be made, if need be, on both sides. It is easily closed and is practically proof against disruption. To close it, interrupted sutures placed some distance apart to facilitate drainage,

should be used. The aponeurosis of the transversalis muscle is the most powerful layer of the abdominal wall above the umbilicus. If its fibers are cut at right angles to their course, it is impossible to unite them securely and a weak wound results, even in the absence of infection.

The second incision, used below the umbilicus, starts about 3 inches to the side of the same, and extends diagonally downwards across the midline to a point about 3 inches to the side of the pubis. The anterior sheaths of the recti are divided in the line of the skin incision, and the recti are retracted from the midline. This is a modified Pfannenstiel incision. It gives complete exposure of the abdomen below the umbilicus and offers much greater resistance to disruption than a simple midline incision.

In case exposure of one upper quadrant and one or both lower quadrants is needed, then both of these incisions, rather than a single long incision, should be used.

The peritoneum can resist almost an unlimited number of bacteria if they are not associated with gross particulate matter. It is therefore necessary to remove blood clots and bowel contents with scrupulous care. Fortunately the latter usually remain not far from the perforation of the bowel. An efficient suction apparatus is an indispensable help. Drainage should seldom be used except in some cases in the abdominal wall. Finally in this field, nothing short of adequate surgery is enough. The patient may not survive it, but he will certainly not survive the lack of it.



# APPENDICITIS\*

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**A**CUTE inflammation of the vermiform appendix is one of the most important surgical emergencies because of its frequency, its amenability to early treatment, and the danger it engenders with improper care. In the United States appendicitis exacts an annual toll of 20,000 lives which is one fatality from appendicitis every twenty-six minutes. Eighty-two per cent of these deaths result from generalized peritonitis, 10 per cent from peritoneal abscesses, and 8 per cent from various other complications. These figures are particularly important when one considers that at least 75 per cent of these fatalities are preventable.

*Etiology.* The etiology of acute appendiceal disease is not known. There are a number of theories which have been suggested to account for its occurrence. Until relatively recently, acute appendiceal disease was considered by most clinicians to be an acute inflammatory process, and the generally accepted theory concerning its causation was that of Aschoff<sup>1</sup> in which the inflammatory process supposedly began at the bottom of an appendiceal crypt, resulting in infection and inflammatory involvement of the appendiceal wall. Recently, Carabba and Baccarani<sup>2</sup> reported an investigation which tends to support the bacterial inflammatory process. They injected *Staphylococcus albus* into the marginal veins of rabbits and sacrificed the animals at various intervals. Histologic sections revealed the presence of the injected bacteria in both the appendix and the tonsils. As early as 1904 Van Zwahlenburg<sup>3</sup> called attention to a mechanical factor, that is, an obstructive lesion, in producing an appendiceal disease. It was

not until the publications of Wilkie,<sup>4</sup> however, that obstructive appendiceal disease was considered of much importance. At the present time it is well known that one must differentiate between the two types of appendiceal disease, that is, an inflammatory lesion, or a true appendicitis, and an obstructive lesion, the so-called obstructive appendiceal disease.

Whereas Wangensteen and Bowers,<sup>5</sup> on the basis of their investigations, are of the opinion that most if not all cases of inflammatory lesions of the appendix are the result of a primary obstruction, probably not all cases can be classified as such. Although one can never say in an individual case or group of cases that an antecedent obstruction was not responsible for initiating the inflammatory process, the occurrence of appendicitis in young individuals during the course of acute upper respiratory infections is suggestive of a pure inflammatory lesion, and in these cases at least the obstruction plays little or no rôle.

Wangensteen and Bowers, after extensive animal experimentation, are of the opinion that an increase in intraluminal pressure is of paramount importance in the production of appendiceal inflammation. They found that when the intra-appendiceal pressure was as high as from 6 cm. to 15 cm. of water and was maintained for six to eighteen hours, acute inflammation of the appendiceal wall occurred which would progress to gangrene. The pathogenesis, as outlined by Bowers,<sup>6</sup> is as follows: "The lumen of the appendix becomes occluded by a slowly enlarging fecalith or by some other mechanism and a closed loop is thus formed. Peristalsis is stimulated as the

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appendix attempts to overcome the obstruction, and the patient notices cramp-like pains in the abdomen. Peristalsis together with the obstruction acts as a secretory stimulus, and the lumen gradually fills with fluid from this source and also from the action of bacteria on its contents. The distention causes pressure on the terminations of the sympathetic nerves, and the patient experiences pain of a more or less constant nature, usually referred to the umbilical region. As distention increases the capillaries and venules become occluded, whereas in the arterioles blood continues to be pumped in at systolic pressure. Vascular congestion follows, and edema and diapedesis of leucocytes begin. The distention has now reached such proportions that reflex nausea and vomiting occur, and the patient has such severe pain that it is recognized as coming from the right lower quadrant of the abdomen. Distention progresses, and inflammatory reaction increases until the terminations of the visceral afferent nerves are killed by pressure or by anoxemia. The pain then becomes less. The distention now has completely shut off the capillaries and smaller veins so that thrombosis occurs. The antemesenteric border has the poorest blood supply. Here, diamond-shaped infarcts develop first. The reaction has now reached the serosa so that the patient experiences pain from peritoneal source, and rebound tenderness with rigidity can be elicited. As more blood is pumped into the appendix, the smaller vessels rupture and hemorrhage occurs. By this time the walls distal to the obstruction are thinned by distention and the mucosa has become ulcerated and destroyed as a result of pressure necrosis. Fever, rapid pulse, and leucocytosis have developed as a consequence of absorption of dead tissue products. As soon as necrosis of tissue appears, bacteria may enter the tissues. If the appendix is not able to overcome the obstructing mechanism, perforation eventuates, usually through one of the infarcted areas on the antemesenteric border. At this

stage the patient experiences relief of pain due to release of pressure."

In 17 per cent of appendicitis cases at the Charity Hospital in New Orleans studied by Mahorner and Vincent<sup>7</sup> a definite obstruction of the appendix was demonstrable. Although there may be some controversy concerning the relative frequency of the existence of infection and obstruction in appendiceal disease, there is little question concerning the importance of differentiation between these two types and the possible prognostic factor which they may have. This will be discussed more in detail under prognosis and treatment.

*Incidence.* Whereas appendicitis may occur at any age, it is largely a disease of young adult life, occurring most frequently in the second and third decades. In the Charity Hospital cases reported by Mahorner and Vincent<sup>7</sup> 41 per cent occurred between the ages of 10 and 20 and the mean age was 19 years. In Bowers<sup>6</sup> series of cases the average age of patients with acute appendicitis was 22 years. The importance of appendicitis at the two extremes of life, particularly as regards the prognosis, has been emphasized by Beekman,<sup>8</sup> and Maes, Boyce and McFetridge.<sup>9</sup>

*Sex.* Males are affected slightly more frequently than females, although there is so little difference that it is probably of little consequence.

*Pathology.* The gross pathologic lesion in acute appendicitis varies considerably. In those cases in which the condition is predominantly of the inflammatory type, there is marked thickening of the appendiceal wall with considerable reaction of the serosal covering. According to Bowers<sup>6</sup> the primary lesion in appendicitis results from the presence of the fecalith obstructing the appendiceal lumen, and at the site of contact of the fecalith with the appendiceal mucosa there occurs a denudation of the mucosa with exposure of the submucosa to the appendiceal lumen. This permits the organisms contained within the lumen of the appendix to penetrate into the submucosa. Once infection has gained

entrance to the submucosa the inflammatory reaction becomes marked because, as emphasized by Bowers, most of the blood vessels are located in this layer. This reaction, consisting of both cellular and fluid exudation, is responsible for the increase in thickness of the appendiceal wall.

The inflammatory process may extend through the wall of the appendix, involving the musculature and also the serosa, although many times the serosa is involved earlier than the appendiceal musculature. As a result of the inflammatory involvement of the submucosa in which most of the vessels are located, there occurs thrombosis of the vessels with resulting gangrene. In those cases in which the lesion is primarily an obstructive one, because of distention, intramural strangulation of the appendiceal vessels can occur with early gangrene before the inflammatory process has extended throughout the wall of the appendix. This is of importance because perforation can and is likely to occur before walling off by serosal protective adhesions can take place. This results in widespread contamination of the free peritoneal cavity. On the other hand, an inflammatory lesion of the appendix, which may even progress to gangrene, everything else being equal, is less likely to result in contamination of the general peritoneal cavity because the localizing inflammatory reaction of the serosal covering of the appendix tends to prevent dissemination of the infection. Maes, Boyce, and McFetridge<sup>10</sup> have emphasized the importance of the obstructive phenomenon in elderly individuals whose vascular system is already occluded.

It is a well known fact that catharsis greatly increases the risk in cases of appendicitis and this is undoubtedly due to the danger of rupturing a diseased viscus which is already inflamed by increasing the intra-enteric pressure. Certainly the change in the intra-appendiceal pressure further interferes with the blood supply to the wall of the viscus, thus further enhancing its tendency toward rupture. Bower et al.<sup>11</sup>

have shown that the mortality rate varies proportionately with the administration of laxatives. In collected cases of peritonitis complicating acute appendicitis, the mortality was 10 per cent in patients who had taken no cathartics, it was 22 per cent when one, and 29 per cent when more than one had been taken. They believe that the mortality is increased when a purgative is taken shortly after the onset of pain. In the Charity Hospital cases of acute appendicitis reported by Mahorner and Vincent,<sup>7</sup> of 145 who had received catharsis 11 per cent died, and of sixty-six receiving no cathartics 1.5 per cent died. Forty-five per cent of the patients admitted with generalized peritonitis stated that one or more cathartics had been administered. Thirty-seven per cent of these died.

*Clinical Manifestations.* The most important symptom in acute appendicitis is abdominal pain, which in the beginning is rather diffuse and located either in the epigastrium or in the region of the umbilicus. This is undoubtedly due to stimulation of the splanchnic nerves, the pain being referred to the region of the celiac plexus. The pain is either constant (stomach ache) or colicky. The latter is suggestive of an obstructive lesion. Colicky pain is particularly significant because of the greater danger of obstructive appendiceal disease. Later the pain becomes localized in the right lower quadrant and is undoubtedly due to the extension of the inflammatory process through the wall of the appendix to the serosa with resultant involvement of the parietal peritoneum. According to Burger and Torbert,<sup>12</sup> approximately 93 per cent of their patients with acute appendicitis had localized pain. Bowers<sup>6</sup> found that in his series of cases colicky pain was present in 31 per cent and constant pain in 56 per cent.

Nausea and vomiting are frequent manifestations and usually follow the onset of pain. Nausea was present in 64.5 per cent of Burger and Torbert's<sup>12</sup> cases and in 90 per cent of Bowers's<sup>6</sup> cases. Vomiting is less frequently present than is nausea. It

was present in only 48.1 per cent of Burger and Torbert's cases and in 60 per cent of Bowers' cases.

As early emphasized by John B. Murphy,<sup>13</sup> the subsidence of pain may be a bad omen and may be the result of a numbing of the nerves as a result of gangrene. This has recently been emphasized by Bower<sup>14</sup> and Bowers.<sup>6</sup> The relief of pain, however, may not necessarily indicate a destruction of the sensory nerves, but may be occasioned by the relief of the obstructing lesion such as the passage of the obstructing fecalith out of the appendix into the fecal lumen. The prompt disappearance of the pain and the subsequent subsidence of all evidences of appendiceal disease are undoubtedly accounted for in this way in many cases.

In addition to the pain, nausea, and vomiting there may be irregularity in bowel habits. Constipation or diarrhea may be present. In Bowers' series of cases constipation was present in 13 per cent.

Maes et al.,<sup>9</sup> and Burger and Torbert<sup>12</sup> have emphasized the bizarre manifestations which acute appendicitis may have in young children. In two of Burger and Torbert's cases the onset of the condition was accompanied by convulsions, and in two other cases there was a violent chill.

On physical examination tenderness is the most prominent and most important diagnostic manifestation. With few exceptions it can be elicited and is of diagnostic importance in localizing the lesion. In Bowers' series of cases it was present in 95.5 per cent. There was little difference in the obstructive and non-obstructive cases as regards the presence of tenderness. Burger and Torbert have emphasized that occasionally, particularly in obese individuals, there may be an absence of positive physical findings. This is particularly true if the appendix is covered over by a thick, fat omentum. In determining the presence or absence of tenderness it is of importance to localize the maximum point of tenderness. Whereas this is considered by most individuals to be over McBurney's

point, in our experience the maximum point of tenderness is over Lanz' point in approximately 70 per cent of cases. Lanz' point is at the junction of the right and middle thirds on a line connecting the two anterior-superior iliac spines.

Of great importance is the performance of a rectal examination, because frequently the tip or even the entire appendix lies in the true pelvis, and can be best palpated through the rectum. This is particularly true in children in whom a rectal examination is of comparatively greater importance because of the ability to insert the examining finger for a relatively longer distance. Rebound tenderness is of importance in the diagnosis of an acute inflammatory process of the abdomen and is indicative of involvement of the peritoneum. Whereas it is present in most cases of acute appendicitis, its presence does not necessarily indicate appendiceal disease.

An important finding in acute appendicitis is fever. However, characteristically, the patient with an uncomplicated appendicitis does not have hyperpyrexia. Generally the temperature varies from 99° to 101°F., and it can be accepted that an individual with hyperpyrexia, unless that individual is a child, either does not have appendicitis or has some complicating lesion. The presence of chills associated with the fever is even more suggestive of a complication of appendicitis such as involvement of the venous radicles, with the possibility of extension into the portal vein. The pulse rate is similarly increased and is in proportion to the elevation of temperature.

Of importance in the diagnosis is the blood count. Characteristically, there is a leucocytosis with an increase in the polymorphonuclear leucocytes. This, as in the case of the temperature, is not excessive, the average ranging from 10,000 to 12,000 per cu. mm. A patient with hyperpyrexia and with a very high leucocyte count is likely not to have appendicitis. On the other hand, we have seen patients, particularly children, with counts as high as 20,000 with obstructive and suppurative

lesions of the appendix in which the exudate was under considerable tension. The disproportionate increase in the polymorphonuclear leucocytes is of importance both from diagnostic and prognostic standpoints. Everything else being equal, the higher the polymorphonuclear leucocytic count, the more severe the infection in spite of the total blood count. In the severe infection there is a shift to the left in the Schilling hemogram. Whereas the presence of an increased leucocytic count is confirmatory in a suspected case of appendicitis, we believe as did the late A. J. Ochsner,<sup>15,16,17,18</sup> that its absence is of no significance. He frequently stated and also practiced that a white blood count should always be made, but no attention should be paid to it provided the other manifestations indicated appendicular disease.

**Diagnosis.** The diagnosis of acute appendicitis is of paramount importance, because if it can be made early before the infection has spread beyond the confines of the appendix and the removal of the diseased viscus accomplished, the mortality rate from appendicitis could be almost negligible. Although the textbook picture of acute appendicitis is quite clear-cut, there are few conditions which offer greater difficulty in making a correct diagnosis.

No one desires to operate unnecessarily, but this is one condition in which operation is justified in suspicious cases. Previously, we were critical of any individual who operated for acute appendicitis and found a normal appendix. At present, however, we believe that if one is honest and thorough in his investigation and cannot exclude the possibility of the existence of an acute appendicitis, immediate laparotomy and appendectomy should be done in those cases in which the infection is apparently confined to the appendix. *Although occasionally the removal of an appendix for some other condition will occur and this is admittedly undesirable, the risk from an unnecessary laparotomy associated with an appendectomy is minimal compared with the risk of overlooking a diseased appendix and*

*permitting it to perforate.* Although the authors take this rather radical stand concerning the need of early operation in all suspected cases of acute appendicitis, and even though they feel that such a condition as chronic appendicitis does exist, they are of the opinion that *extirpation of an appendix for chronic appendicitis should be done only after exhaustive search has failed to reveal other causes of the symptoms.*

It is imperative to differentiate acute appendicitis from acute pelvic disease, particularly because in the former immediate operation is necessary and in the latter conservative treatment is indicated. In an individual case, however, in which one cannot differentiate satisfactorily on physical findings, laparotomy should be performed, although generally a patient with acute salpingitis has a higher temperature, a higher leucocyte count, appears much sicker, and has tenderness over and limited to the involved adnexa. In case of doubt, laparotomy should be done in order not to overlook a possible appendiceal process. In the event the lesion proves to be salpingitis, closure of the abdomen with the institution of conservative therapy should be done.

Particularly in children, mesenteric lymphadenitis should be considered. Here, too, the temperature is likely to be higher and the leucocyte count greater than in a case of appendicitis. Also of importance is the presence of tenderness along the root of the mesentery, that is, along a line extending from the region of McBurney's point obliquely upward and to the left, passing just above the umbilicus. As acute mesenteric lymphadenitis in children is frequently associated with appendicitis, we feel that many of these patients should be operated upon and the appendix removed. We have observed many cases in which the manifestations of the mesenteric lymphadenitis have subsided completely following appendectomy.

Acute urinary infections, particularly pyelitis or ureteral calculi, must be ex-

cluded, since not infrequently the two conditions give similar manifestations. An inflammatory process involving the ureter may give identical symptoms to an inflammatory process in an overlying appendix. Conversely, a diseased appendix by producing an acute inflammation of the ureter may give rise to symptoms referable to the urinary system and even result in hematuria.

That acute suppurative processes within the appendix can occur without characteristic evidence is shown by the statistics of Shelly,<sup>19</sup> who found in 2,065 consecutive incidental appendectomies, acute appendicitis and suppuration without objective or subjective evidence, in 1.7 per cent of the cases. A case with bizarre manifestations is reported by Barber<sup>20</sup> whose patient had an acute mania. Within three weeks following removal of a gangrenous appendix, there was dramatic recovery of the patient's mentality and a return to normal.

Atypical manifestations are likely to occur at the two extremes of life. McLaughton and Davis<sup>21</sup> have emphasized that because of the large amount of lymphoid tissue in the appendix and the thinness of its wall in children, perforation occurs early and is likely to progress rapidly to generalized peritonitis because the underdeveloped omentum offers little resistance to the invading micro-organisms. Deaver and Martin<sup>22</sup> state that it is not uncommon to find a perforated appendix in a child who has been sick less than twelve hours and that appendicitis following gastroenteritis is not only difficult to diagnose, but is likely to be fulminating in character. Appendicitis in the aged also offers considerable difficulty in diagnosis. The abdominal pain and tenderness are frequently less marked than in younger persons. As suggested by Holman,<sup>23</sup> the symptoms in elderly persons with appendicitis frequently suggest intestinal obstruction.

**Treatment.** As mentioned above, there is only one treatment of acute appendicitis and that is immediate extirpation of the involved viscus before extension has oc-

curred beyond its confines. If this is done, the mortality rate from appendicitis will become virtually negligible. In cases of uncomplicated acute appendicitis in which the infection has not extended beyond the confines of the appendix immediate appendectomy should be done. We believe that a muscle-splitting incision, either the McBurney<sup>24</sup> or the Rockey<sup>25</sup>-Davis,<sup>26</sup> should be used. Before the removal of the appendix the abdominal wound edges should be protected by placing moist cloths or rubber sheets into the peritoneal cavity and allowing them to protrude from the abdominal wound. In this way the abdominal wall, which is more susceptible to infection than the peritoneum, is protected from possible contamination.

As previously emphasized by Ochsner and Lilly,<sup>27</sup> the method of handling the appendiceal stump is of paramount importance, in order to prevent sequelae. Of the three techniques of treating the appendiceal stump, (1) simple ligation, (2) ligation and inversion, and (3) inversion without ligation, inversion without ligation is the only one which is surgically sound. Simple ligation is particularly dangerous because of the possibility of the stump blowing out, a complication which we have seen several times. Ligation and inversion is also dangerous because the contaminated ligated stump is buried in a closed cavity which may give rise to a localized suppurative process and peritonitis by rupture into the peritoneal cavity. The inversion without ligation technique is surgically sound and is not accompanied by sequelae.

The technique of appendectomy which we have employed for years was previously described by Ochsner and Lilly<sup>27</sup> as follows:

"Before proceeding to the removal of the appendix, moist cloths are inserted around the wound down to and into the peritoneal cavity, completely walling off the abdominal wall from the appendix. In this way contamination of the abdominal wall, which has little resistance to infection, is prevented. Traction is applied to the tip of



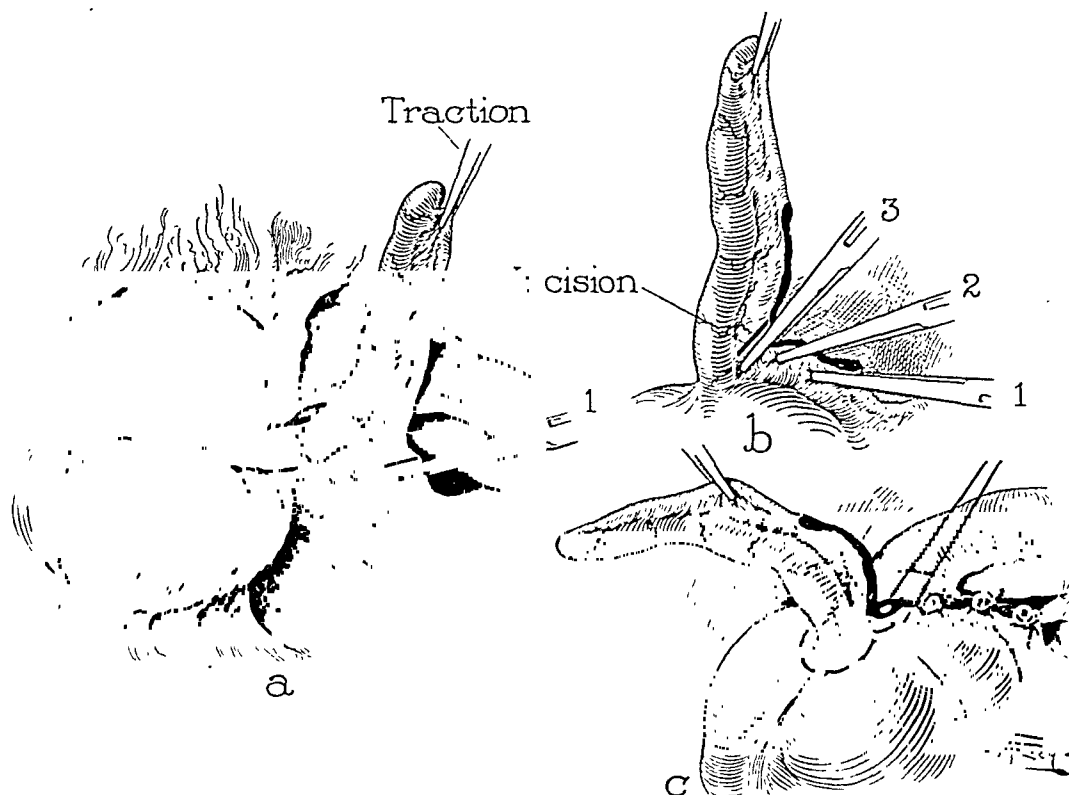


FIG. 1. Technique of appendectomy. Mesoappendix is grasped by several hemostats and divided. Each portion which is grasped in individual hemostats is ligated with silk. (From Ochsner and Lilly, in *Surgery*, 2: 532, 1937.)

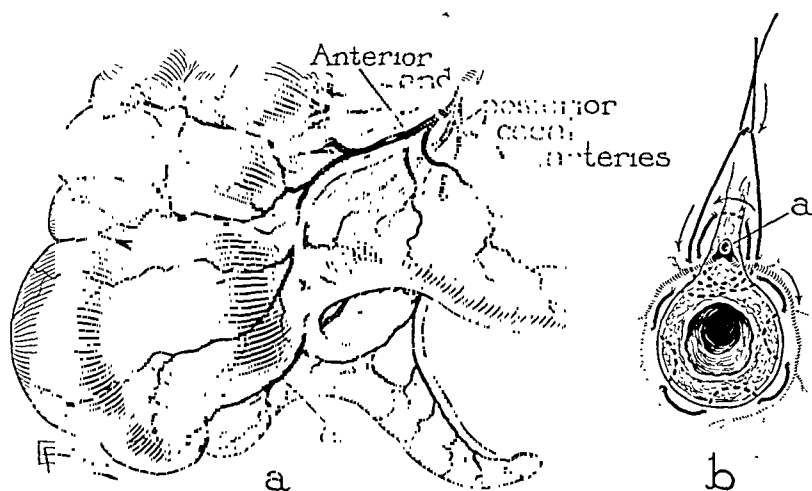


FIG. 2. Technique of introducing purse-string suture around the base of the appendix. This is done in such a way as to include any intramural branch of the appendiceal artery. *b*, the purse-string suture begins at the mesenteric attachment passing into the submucosa. It emerges on the opposite side of the mesenteric attachment to be reintroduced on the original side. In this way a loop is made around any intramural branch of the appendiceal artery. The purse-string is then continued around the base of the appendix in the conventional manner. (From Ochsner and Lilly, in *Surgery*, 2: 532, 1937.)

the appendix by grasping the mesoappendix with a hemostat and lifting it upward. This affords an adequate exposure of the

artery. (Fig. 2.) This loop suture is tightened to occlude any arterial branch which may be present, and the purse-string suture

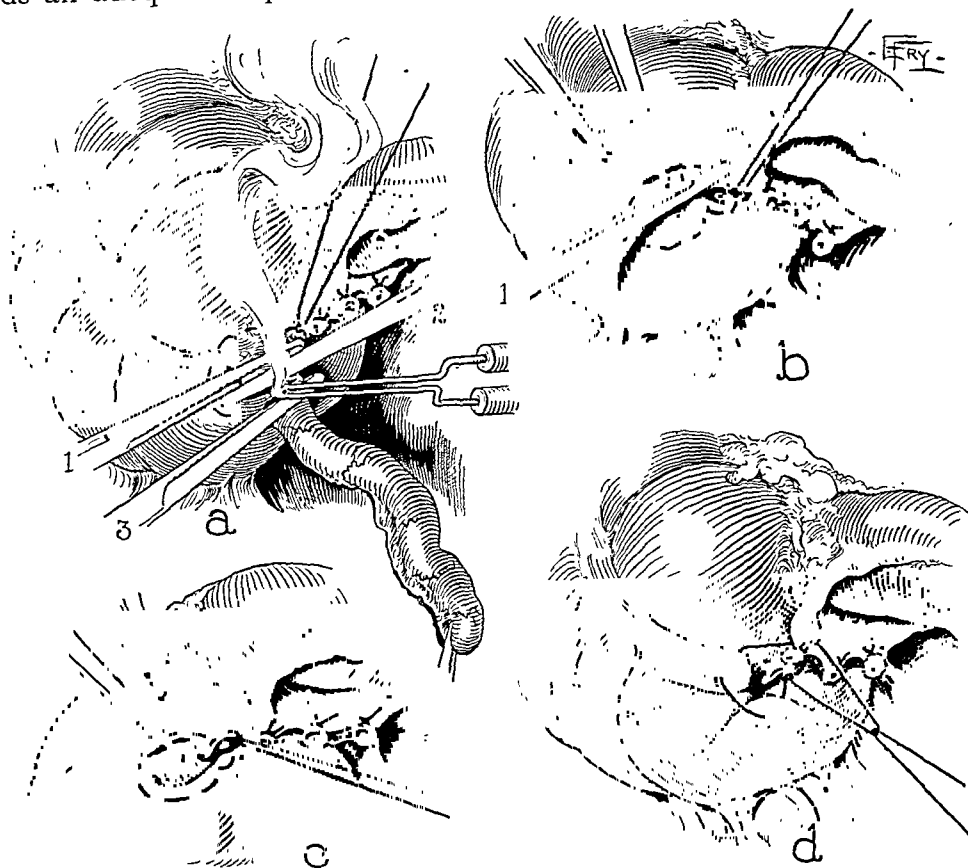


FIG. 3. Technique of appendectomy. After introducing the purse-string, as shown in Figure 2, three crushing clamps are applied to the base of the appendix, and the appendix divided between the upper and the middle clamp leaving two clamps on the appendiceal stump. One of these clamps is removed, permitting the crushed portion to be grasped by means of smooth forceps (*b*) before the last clamp is removed. This prevents any possible contamination during this manipulation. The last clamp is removed (*c*) and the non-ligated stump is inverted into the lumen of the cecum, and the purse-string suture tightened. The inverted area is further inverted by several Lembert sutures (*d*). (From Ochsner and Lilly, in *Surgery*, 2: 532, 1937.)

mesoappendix, which is clamped, divided, and ligated with fine silk ligatures. (Fig. 1.) A purse-string suture of No. 1 silk on an atraumatic needle is then introduced in such a way as to include an intramural branch of the appendicular artery. This is accomplished by beginning the purse-string suture on one side of the mesoappendix so that it passes down to and includes the submucosa and emerges from the opposite side of the mesoappendix. The suture is reinserted in the same manner, forming a loop around the mesenteric portion of the cecal wall and encircling any intramural branch of the appendicular

is continued around the cecum in the conventional manner. After the introduction of the purse-string suture, three Ochsner clamps are applied to the base of the appendix, and the area is walled off with moist gauze packs to avoid any possibility of contamination or injury to the surrounding structures. The appendix is divided by means of the thermocautery between the distal two clamps. (Fig. 3A.) By means of a sponge, the cauterized portion is wiped away from the middle forceps. The middle clamp is then removed and the crushed tip of the stump thus exposed is grasped with a pair of plain tissue forceps before

removing the third crushing clamp. (Fig. 3B.) Traction is then made on the fixed end of the purse-string suture by pulling upward on this side of the suture, and traction is also made at a point on the cecal wall opposite this point by catching a tenial band with a pair of toothed tissue forceps and lifting it upward. (Fig. 3C.) The remaining Ochsner clamp is then removed, and the stump of the appendix is inverted through the purse-string suture into the cecal lumen by pushing it downward with the smooth tissue forceps with which it has been held (Fig. 3C.) The purse-string suture is drawn tightly as the tissue forceps are gently freed and withdrawn. The site of the inverted stump is carefully compressed with a sponge and the purse-string suture is tied. The site of the inversion is then reinforced by installing several Lembert sutures over the area of inversion and by suturing the stump of the mesoappendix over this same area. (Fig. 3D.) In this way the hemorrhage from an intramural branch of the appendicular artery is prevented by a loop in the purse-string suture around it; spillage during inversion is prevented by the use of three crushing clamps, which permit grasping of the crushed appendiceal stump before the last clamp is removed; and subsequent peritoneal infection is prevented because the infected stump is inverted into the cecal lumen and is not buried within the wall of the cecum."

In case contamination occurs, due to rupture of a gangrenous appendix during appendectomy we use the coli-bactragen of Steinberg<sup>28</sup> and have found it effective in preventing peritonitis. This, however, is not recommended when generalized involvement of the peritoneum is already present.

Unfortunately, many cases of appendicitis are not seen at a time in which the appendix can be removed before extension has occurred. It is in these cases that the mortality rate is high, and it is also in these cases that other forms of therapy can and should be used. Whereas the late A. J.

Ochsner<sup>15,16,17</sup> described the delayed treatment of appendicitis, he did not treat acute appendicitis conservatively. He was just as ardent an advocate of the immediate extirpation of an acutely inflamed appendix as any surgeon today. He did emphasize, however, the desirability of treating conservatively certain cases with complicating peritonitis in which the peritonitis was the most important factor. Although at the present time there are many who believe that all cases of appendicitis, irrespective of the time which they are seen and irrespective of the presence or absence of complications should be operated upon immediately, there is a gradual trend toward a more rational conception of the treatment of the complications of appendicitis, and the results obtained justify this change.

Stanton<sup>29</sup> reports 113 cases of acute appendicitis complicated by peritonitis, with a combined mortality rate of 17.6 per cent. Of thirty-one treated by immediate operation, thirteen died (forty-two per cent), whereas of eighty-two patients who were treated conservatively and later operated upon, only seven died (8.5 per cent). Of importance also is the fact that the more desperately ill patients were treated conservatively.

Coller and Potter<sup>30</sup> estimate an average mortality of 28 per cent for immediate operation in generalized peritonitis, with variations from 15 to 65 per cent. After adopting the policy of deferred operations the fatalities in their series of eighty-five cases dropped to 9.3 per cent. Young<sup>31</sup> finds the death rate approximately the same in each of his two groups; however, he adds that six of the seven fatalities occurring in the conservatively treated group of fifty-five (mortality 12.7 per cent) were patients admitted in extremis. With these excluded, his delayed surgery mortality would be 2 per cent as compared to the 12.6 per cent mortality encountered in the 333 treated by immediate operation.

Guerry,<sup>32</sup> in 1926, had a mortality of 8.2 per cent in eighty-five cases of peritoni-

tis treated by immediate operation as compared to 1.6 per cent in 123 in which surgical intervention was delayed. In 1932, this same author<sup>33</sup> was able to reduce the mortality in his 128 delayed cases to 1.5 per cent, while in the series of ninety-three operated upon at once, the death rate rose to 10.75 per cent. Two years later,<sup>34</sup> the rates were 1.4 per cent in the delayed group of 135, and 10.6 per cent in ninety-four patients upon whom immediate operation was done.

Walker's<sup>35</sup> seventy-seven cases operated upon at once had a mortality of 42 per cent, while delayed surgery in thirty instances reduced the fatal outcome to 13 per cent. Adams and Bancroft<sup>36</sup> have employed delayed surgical procedures beneficially in children. Comparing the results published by Tasche<sup>37</sup> in the same hospital, covering the decade 1920-1929, during which time immediate operation was practiced, they find a mortality reduction from 10.14 per cent to 4.5 per cent resulting from conservative treatment with deferred surgery.

Gardner<sup>38</sup> divided his series of 248 cases of appendiceal peritonitis into two periods, viz., when delayed operation was used only occasionally, and when it was relied upon consistently except in children with generalized peritonitis. The mortality fell from 18 per cent to 8.7 per cent after adoption of the delayed operation method of treatment.

The rationale of the conservative treatment of appendiceal peritonitis is based upon the fact that trauma to the peritoneum and other serous membranes results in marked exudation of fluid rich in fibrin, which if left alone will wall off the originating infection and limit its extension. The injudicious operation with the breaking down of peritoneal adhesions tends to disseminate the localizing infection and produce a generalized peritonitis.

There is probably nothing more difficult than the conservative treatment of appendiceal peritonitis, and we are thoroughly in accord with Nuttall<sup>39</sup> that this method of therapy is a great strain on the

surgeon and the house staff. We also believe that it is no method of therapy to be employed by the occasional operator who would do far better by operating immediately upon all cases of appendicitis, irrespective of the time they are seen. There is nothing that requires more careful supervision and greater surgical judgment than the conservative treatment of appendiceal peritonitis. The increased strain on the surgeon and his house staff is largely due to the fact that these patients live longer than the patients who are operated upon immediately and live long enough to worry the surgeon over a longer period of time. *It is far better, however, to have a living patient who may develop a complication but who ultimately will recover than to have that individual die within a short period of time after the operative procedure.*

If the patient is seen shortly after rupture and if there is no evidence of localization, immediate operation should be done, because the conservative treatment of appendiceal peritonitis is indicated only in those cases in which beginning localization has occurred. Where there is difficulty in differentiating between the case which is localizing and that in which there is continued spreading of the peritonitis, laparotomy should be done and, if at the operation a localized lesion is found, one should not hesitate to close the abdominal wound without appendectomy. This takes considerable fortitude because of the criticism arising from performing a laparotomy in a case of an acute appendicitis without removing the appendix. By the institution of adequate conservative therapy, however, one will be amply repaid.

In children, localization is less likely to occur than in adults because of the massive contamination of the peritoneal cavity and the relatively small omentum. Because of this, we feel that all children suspected of having peritonitis, and without definite localization, should be operated upon immediately. If the appendix is walled off, it is left alone; if it is not, appendectomy

is done. The advantage of this is shown by the two following cases:

A 9-year old girl in whom advanced acute appendicitis or early rupture had to be considered was operated upon. Upon opening the peritoneal cavity, a large amount fluid exudate and intestinal contents was encountered. The appendix was free, with no evidence of any walling-off, and was draining its contents through a perforation in its midportion. The appendix was removed, and the patient recovered.

Another case of peritonitis in a child of the same age was treated conservatively with a fatal outcome. At necropsy no localization of process was found. A perforation in the appendix was still patent and draining intestinal contents.

The conservative treatment of appendiceal peritonitis consists of placing the gastrointestinal tract at complete rest and producing functional inactivity. The patient is placed in Fowler's position, permitting gravitation of the peritoneal exudate into the cul-de-sac, where it can be more readily watched and where a suppurative process can be more easily drained. In all cases there is an associated ileus of the adynamic variety. In order to combat this, an indwelling duodenal catheter should be introduced and continuous suction applied. This removes the secretions which stagnate in the stomach and duodenum and prevents nausea and vomiting.

Large doses of morphine are given in order to increase the intestinal tone. As originally used in the treatment of typhlitis, large doses of opium were thought to splint the bowel. It is now known, as a result of the investigations of Plant and Miller,<sup>40</sup> Orr and Carlson,<sup>41</sup> and Ochsner, Gage, and Cutting<sup>42</sup> that morphine exerts a markedly stimulating effect on intestinal tone. Generally, in the case of adults  $\frac{1}{4}$  to  $\frac{1}{2}$  gr. of morphine is given every three to four hours.

Oxygen is administered either by means of a nasal catheter or by the Lombard mask. Prior to the fundamental investigations of Fine et al.<sup>43</sup> we used oxygen

because we felt that it was undesirable to produce anoxemia by the depressing effect of morphine on the respiratory center. These authors demonstrated, however, that oxygen exerts a beneficial decompressive effect on gut and should be used in all cases of ileus.

Because the patients lose considerable fluid insensibly and through the stomach and duodenum, they require relatively large amounts of fluids and electrolytes. They should receive infusions of saline and glucose, the amount varying from two to four liters daily. Careful chemical examinations of the blood, particularly as regards the non-protein nitrogen, blood chloride, and  $\text{CO}_2$  combining power should be made. Heat is applied to the abdomen either by means of electric pads or a heat tent. Heat is of benefit in the treatment of the adynamic ileus because application of heat to the abdominal parietes produces vasodilatation in this area and a concomitant vasoconstriction in the splanchnic area. This is associated with a decrease in the intestinal secretion and an increase in intestinal tone.

Careful examination of the patient should be made daily in order to detect the possibility of development of localized suppurative processes in various portions of the peritoneal cavity. The sites at which localization is likely to occur are (1) the cul-de-sac of Douglas; (2) the right iliac fossa; (3) the subphrenic area, both above and below the liver; and (4) on the left side. These will be discussed more in detail under complications. In order to detect the possibility of localizing infections in these areas, repeated rectal examinations should be made. Careful examination of the abdomen should be made, paying particular attention to tenderness and rigidity in the right iliac fossa, over the right twelfth rib, along the right costal margin, and in the left iliac fossa.

*Complications.* The intraperitoneal localizations which were enumerated above are the most frequent complications of acute appendicitis. In addition to these is a

relatively infrequent complication, but one which is of importance, viz., portal thrombophlebitis or pylephlebitis.

Whereas localization of intraperitoneal infections occurs not infrequently in cases of peritonitis, relatively few of them go on to suppuration. As previously emphasized (Ochsner<sup>44</sup>), the incidence of suppuration in the localized intraperitoneal infections is approximately 25 per cent. Those cases which subside are likely to be overlooked unless one considers their possibility and is on the lookout for them. Cul-de-sac infections are diagnosed by the finding of a bulging in the anterior wall of the rectum on rectal examination. This is due to the presence of fluid in the cul-de-sac of Douglas. Of diagnostic importance is the relaxation of the anal sphincter, which normally offers considerable resistance to the examining finger. The patient may complain of a sense of fullness in the rectum and may have an urgency to defecate and urinate due to the associated proctitis and cystitis. On examination, in addition to the bulging in the anterior wall of the rectum, there is not infrequently a succulence of the mucosa on the anterior rectal wall due to the edema in this area. Under conservative therapy, consisting of the treatment outlined for general peritonitis and also application of heat to the rectum, most cul-de-sac infections subside spontaneously. In approximately 25 per cent of instances suppuration occurs, and when it does, incision and drainage must be done. Suppuration of a cul-de-sac infection is indicated by the persistence of the systemic manifestations of infection, such as fever and leucocytosis, and an area of softening in the indurated bulging mass on the anterior wall of the rectum. This is best compared to a rotten spot in an otherwise normal apple. If one were to move his finger along the surface of the apple, which offers considerable resistance to the palpating finger, and then palpate the rotten area, one could appreciate the sensation imparted by a cul-de-sac infection which has undergone suppuration. The soft area

is the location at which pointing into the rectum has occurred.

Incision and drainage of a cul-de-sac abscess is best accomplished through the rectum in both sexes. Generally, no anesthesia is necessary because of the marked relaxation of the anal sphincter. After careful dilatation of the sphincter a large needle which is attached to a syringe is introduced into the soft area described above. (Fig. 4.) One need have no fear of penetrating loops of bowel, because they, with their gaseous contents, float above the fluid. After pus has been aspirated from the abscess cavity, an incision is made longitudinally in the anterior rectal wall along the aspirating needle and the abscess opened widely by means of blunt forceps. A fenestrated rubber tube is inserted into the abscess cavity and conducted out through the rectum.

The second most frequent complication of appendiceal peritonitis is ileocecal infection. Many cases of appendicitis with rupture which have become localized develop a peritonitis in the region of the ileocecum and do not progress to a generalized peritonitis. The manifestations are the same in both. There is a mass which is present in the right iliac fossa, usually in the region of McBurney's point. There is marked tenderness in this area with muscular rigidity. There are also systemic signs of infection, such as fever and leucocytosis. Here, as in other portions of the peritoneal cavity, most of these conditions will subside spontaneously and not progress to suppuration. In only about 25 per cent of instances does suppuration occur. In cases in which the localized infection does not progress to suppuration the mass which is palpable is usually made up of loops of bowel and the omentum around the perforated appendix. In the beginning before suppuration occurs, the conservative treatment for peritonitis should be instituted. If the systemic manifestations of infection do not subside, if the leucocyte count increases, and if the temperature becomes hectic, one may conclude that

suppuration has occurred and that incision and drainage are necessary. In draining such an abscess, it is imperative that an

plished by making an oblique incision lateral to or on the lateral aspect of the mass and approaching the mass extraperi-

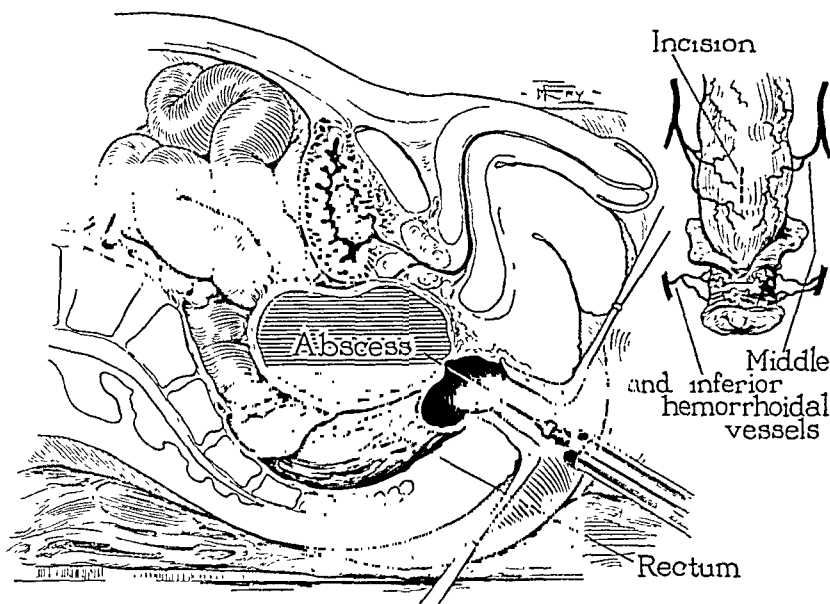


FIG. 4. Technique of drainage of cul-de-sac abscess. After dilatation of the sphincter an aspirating needle is introduced into the softened area of pointing on the anterior wall of the rectum. As shown in the drawing, there is no danger of perforating any loop of bowel, because they are floated above the abscess. After pus has been aspirated a longitudinal incision is made alongside the needle, as shown in the insert. In this way the hemorrhoidal vessels are avoided. The opening is widened by means of dressing forceps and a rubber drainage tube inserted into the abscess cavity.

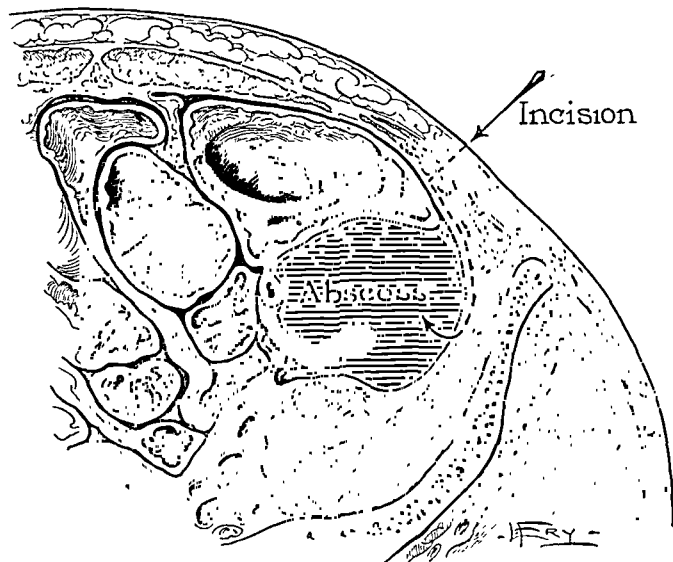


FIG. 5. Technique of extraperitoneal drainage of right ileocecal abscess. Incision is made laterally and the peritoneum peeled away from the abdominal parietes until the abscess is reached. In this way drainage of the abscess is secured without danger of peritoneal contamination.

uninvolved portion of the peritoneum is not contaminated. This is generally accom-

plished by making an oblique incision lateral to or on the lateral aspect of the mass and approaching the mass extraperi-

incision made more laterally in order to drain the abscess extraperitoneally. One should never attempt to remove the

analyzed a series of 3,608 cases of subphrenic abscess, most of which followed appendiceal infection. In Ochsner and

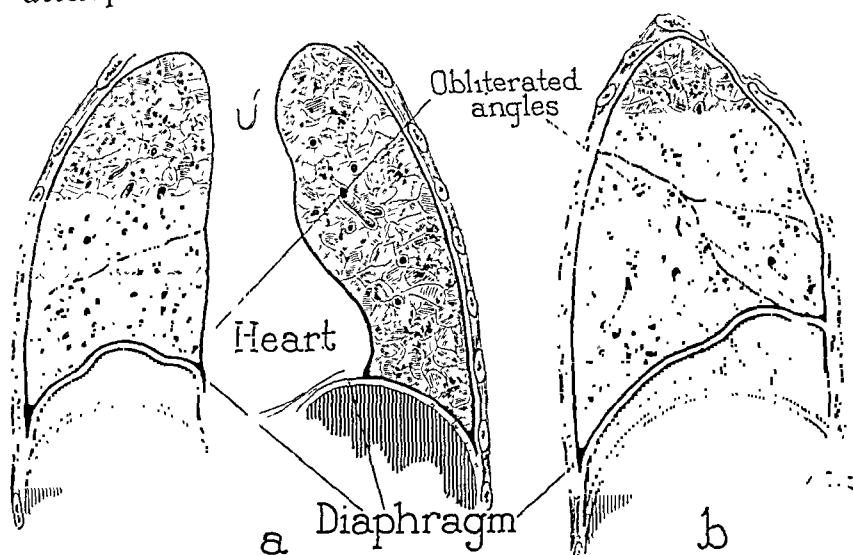


FIG. 6. Diagrammatic drawing showing the characteristic roentgenographic changes in abscesses of the right posterior superior subphrenic space. In the anterior-posterior roentgenogram (a) there is elevation of the lateral half of the diaphragm with obliteration of the costophrenic angle. In the lateral roentgenogram (b) there is elevation of the posterior portion of the diaphragm with obliteration of the posterior costophrenic angle.

appendix in drainage of such an abscess unless it lies perfectly free within the cavity and can be removed without breaking down any adhesions.

Another complication of appendiceal peritonitis is subphrenic abscess, the importance of which has been insufficiently appreciated. This is largely due to the fact that infections of the subphrenic space as elsewhere in the peritoneal cavity usually subside spontaneously; and, unless one is on the lookout for it, the possibility of its existence is likely to be overlooked and the diagnosis made only in those cases which go on to suppuration. There are certain sites in the subphrenic area in which postappendiceal infections are particularly likely to localize. The anatomy of the subphrenic space has been described in previous reports (Ochsner, Graves, and DeBailey). In 1933, Ochsner and Graves<sup>45</sup> analyzed 3,322 cases of subphrenic abscess collected from the world literature and fifty additional cases treated at Charity Hospital and the Touro Infirmary in New Orleans. Recently, Ochsner and DeBailey<sup>46</sup>

DeBailey's<sup>46</sup> series there were approximately 15,000 collected cases of acute appendicitis, of which subphrenic abscess occurred as a complication in about 0.9 per cent. These represent only those cases which had progressed to suppuration and did not include the much larger group of subphrenic infections which subsided spontaneously and which were not diagnosed.

The subphrenic spaces which are most likely to become involved in postappendiceal infections are the right posterior superior space, which is a small triangular area located above the liver, to the right of the suspensory ligament and behind the right prolongation of the coronary ligament in immediate contact with the diaphragm. This space is immediately beneath the right twelfth rib. The next most frequently involved space is the right inferior space, which is located below the liver, above the transverse colon and transverse mesocolon, to the right of the ductus venosus, and in the general peritoneal cavity. In a patient who has had an intraperitoneal suppuration, particularly appendicitis, repeated



examinations of the subphrenic area should be made, particularly pressure over the right twelfth rib and pressure along the

anterior costophrenic angle, and in anterior-posterior roentgenograms (Fig. 6A) an obliteration of the costophrenic angle and

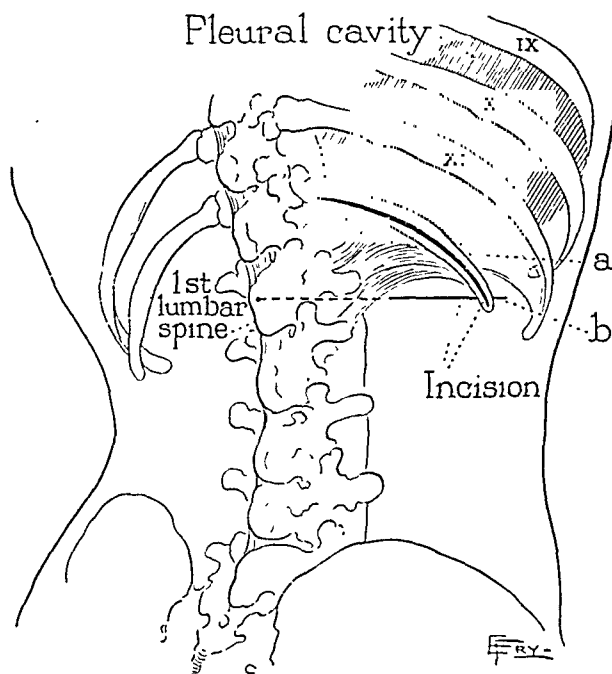


FIG. 7. Retroperitoneal operation for subphrenic abscess. a, incision through the skin over and paralleling the twelfth rib. The twelfth rib is resected subperiosteally following which a transverse incision is made through the bed of the twelfth rib at the level of the spinous process of the first lumbar vertebra. In this way there is no danger of injury to the costophrenic reflexion of the pleura. (From Ochsner and Graves, in *Ann. Surg.*, 98: 961, 1933.)

anterior costal margin. A persistence of tenderness over the right twelfth rib on deep pressure, together with the persistence of systemic manifestations of infection in a patient who has or has had a recent appendiceal infection, is suggestive of subphrenic infection with involvement of the right posterior superior space. Similarly, tenderness along the right costal margin is indicative of involvement of the right inferior space. As mentioned above, most of these cases subside spontaneously under conservative therapy. Of diagnostic importance is the immobility and slight elevation of the diaphragm. In the right posterior superior space infections, there is in lateral roentgenograms (Fig. 6B) an elevation of the posterior portion of the diaphragm with obliteration of the pos-

elevation of the lateral portion of the diaphragm. Gas under the diaphragm is infrequently found.

If the systemic manifestations of infection in a suspected case of subphrenic infection do not subside, the temperature becomes hectic, and the leucocytosis increases, one is justified in making a diagnosis of suppuration in the subphrenic space, which should be treated by incision and drainage. The drainage should be done in such a way as to prevent contamination of an uninvolved serous cavity. This is particularly important in subphrenic space infections because of the frequently employed transpleural drainage which is likely to result in contamination of the pleura with dire consequences. The importance of this is shown by the collected

statistics of Ochsner and DeBakey<sup>46</sup> in which it was found that in 211 cases in which retroperitoneal method of drainage

infection is present, extraperitoneal drainage can be obtained anteriorly by an incision along the costal margin.

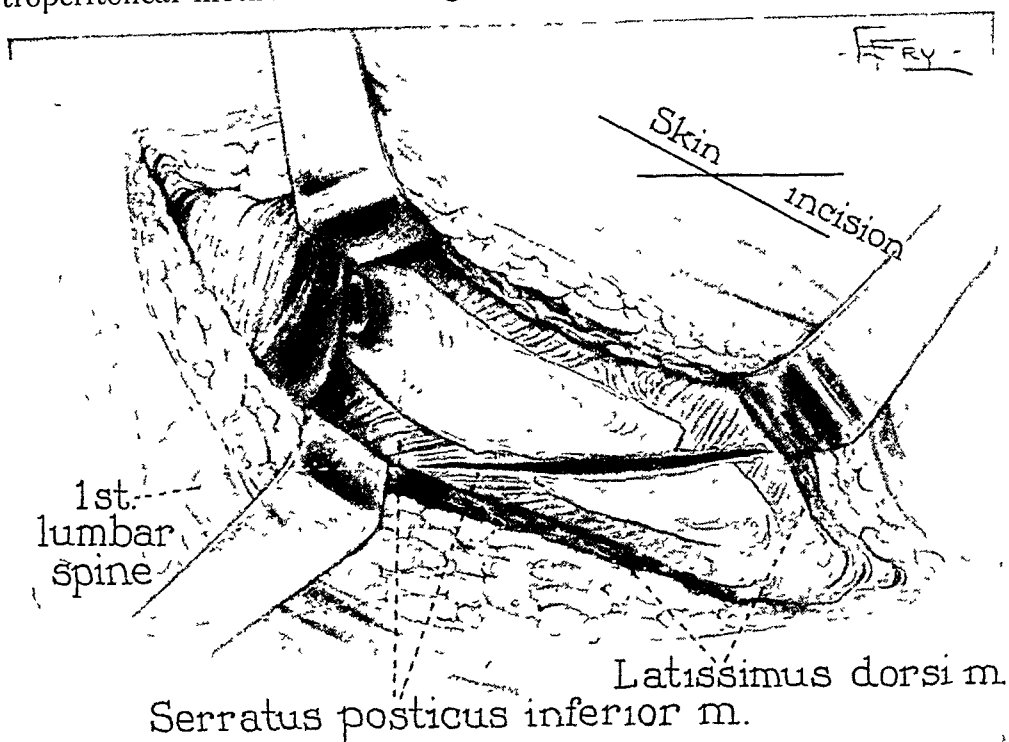


FIG. 8. Drawing showing the relative positions of the skin incision and the transverse incision through the bed of the twelfth rib at the level of the spinous process of the first lumbar vertebra. The latter incision is extended through the attachment of the diaphragm. (From Ochsner and Graves, in *Ann. Surg.*, 98: 961, 1933.)

was employed there were forty-four deaths (20.8 per cent), as contrasted with the respective mortality rates of 36.2 per cent and 35.1 per cent, in 394 cases drained transpleurally and in 327 cases drained transperitoneally. Of Ochsner and DeBakey's<sup>46</sup> personal series of seventy-five cases there were thirty-seven drained by the retroperitoneal method with four deaths (10.8 per cent). Still more significant is the fact that in the recent series of cases reported by them<sup>46</sup> there were twenty-five cases, of which fifteen were drained retroperitoneally with only one death (6.6 per cent). The extraserous drainage consists, in the right posterior superior space infections, of employing the retroperitoneal operations previously reported by the authors<sup>47-50</sup> to which the reader is referred. (Figs. 7, 8 and 9.) Through this incision a right inferior space infection can also be drained. If only the right anterior space

Relatively infrequently there occurs in children an abscess on the left side which is located usually midway between the left anterior superior iliac spine and the umbilicus or slightly below this level. Its development is due to the fact that because of the shallowness of the cul-de-sac of Douglas in the child the infection rises out of the cul-de-sac and becomes localized on the left side. The clinical manifestations are the same as for a right ileocecal abscess except that the localization is on the left. The treatment consists of ultraconservatism, as most of these cases subside spontaneously and relatively few go on to suppuration. In those cases in which suppuration does occur, incision and drainage in such a way as to prevent contamination of an uninvolved portion of the peritoneal cavity should be done.

The last, and fortunately the least frequently encountered, complication of sup-

purative appendicitis is pylephlebitis or portal thrombophlebitis, a complication which occurs in about 5 per cent of the

A patient with acute appendicitis who develops chills should be suspected of having a portal thrombophlebitis and

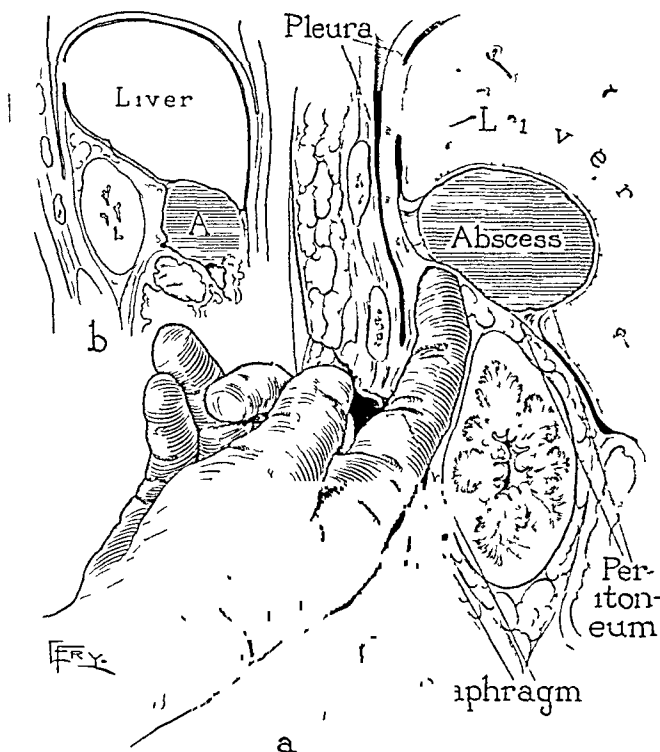


FIG. 9 Method of draining a right posterior superior space infection by means of retroperitoneal operation. The peritoneum is peeled from the under surface of the liver until the abscess is reached. The finger is then plunged through the abscess wall, and the cavity drained. In instances in which there is an abscess in the right inferior space (b), the abscess can be drained through the retroperitoneal approach by depressing the kidney downward and draining the abscess extraperitoneally. (From Ochsner and Graves, in *Ann. Surg.*, 98: 961, 1933)

fatal cases of acute appendicitis and in from 1 to 3 per cent of the clinical cases. The clinical manifestations are those of a severe infection, usually consisting of high fever and recurrent chills. These episodes are due undoubtedly to invasion of the portal system by the inflammatory process and possibly the breaking off of infected emboli which are carried to the liver. The process may be a propagating one with extension of the thrombosis from the appendiceal veins up through the portal radicles and even to the liver. There may occur, as a result of invasion of the liver by infected emboli, multiple liver abscesses.

should be operated upon immediately. An attempt should be made to get above the involved segment of vein and to ligate the vein to prevent further propagation of the process. Within the past two years we have observed two cases in which the pre-operative diagnosis of pylephlebitis was made and in which at operation a definite thrombosis of the appendiceal veins and its tributaries was found. An attempt was made to get above the thrombosed areas, but this was impossible. The appendix was removed, and subsequently leeches were applied to the patient. Eight leeches were applied daily until the patient's tempera-

ture was normal, which in these two instances was on the fourth and fifth days respectively. It is impossible to say just what rôle the leeches played, but it is our firm conviction, based upon the beneficial effects obtained with leeches in thrombophlebitis of the extremities<sup>51</sup> and also because of our experience in other cases of portal thrombophlebitis which were very disappointing, that the leeches were of distinct benefit.

#### SUMMARY AND CONCLUSIONS

1. Death from appendicitis is largely preventable. Removal of an acutely inflamed appendix while the infection is still confined to the viscus is associated with an almost negligible mortality.

2. Two types of acute appendiceal disease exist, the inflammatory and obstructive. Obstructive appendiceal disease is more dangerous than the inflammatory type because the diagnosis is likely to be delayed and wide spread contamination of the peritoneal cavity follows rupture.

3. The treatment of acute appendicitis is immediate appendectomy, preferably using the inversion, non-ligation of the stump technique.

4. Many cases with peritonitis complicating acute appendicitis are best treated non-operatively.

5. Localization is likely to occur in particular areas of the peritoneum in appendiceal peritonitis. These are (1) cul-de-sac of Douglas; (2) right ileocecal fossa; (3) subphrenic area; and (4) left iliac fossa. Most of these subside spontaneously. If suppuration occurs, incision and drainage in such a way as to prevent contamination of uninvolved serous membranes is necessary.

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# ACUTE CHOLECYSTITIS

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**D**URING the last several years there has been an increasing surgical literature dealing with the management of patients suffering from acute cholecystitis. The general tendency of the communications has been to urge precipitate operation with such a diagnosis. There has been, however, great variance in what is meant by an emergency operation, and indeed as to whether emergency operation is but rarely necessary.

In the surgical service at the Toronto General Hospital, emergency operations for acute cholecystitis are not advocated by the university staff. By emergency operation is meant immediately to carry out the procedure, regardless of the condition of the patient or the duration of the disease. The continued publication of data by men of unquestioned repute, experience and sound surgical judgment, urging that patients suffering from acute cholecystitis be considered as suffering from a disease demanding as immediate operative interference as though they were suffering from acute appendicitis, is so at variance with this practice that a survey of all cases admitted to the hospital, medical and surgical, from July 1, 1926 to January 1, 1934 was made and published (*Canad. M. A. J.*, 32: 283, 1935). The result of this study of our own material was such as to justify the continued conservative management of this group of patients. This material has now been analyzed further from the first of January 1934 to the first of July 1939. In this last survey, we did not concern ourselves with cases which were not admitted to the surgical wards, feeling, as will be shown, that our medical staff coöperated with the surgical staff so completely, that consultation was held on all patients, and surgical therapy was carried out whenever it was advised by the surgical

staff. This last group is confined to the patients admitted to the First Surgical Division, together with the private patients operated upon by the author. This entire series presents 273 cases. The total hospital deaths were sixteen in this group, including: (1) patients who refused operation; (2) patients who were not advised to be operated upon; (3) those who were submitted to operation. This gives a gross mortality of 5.8 per cent.

TABLE I

		Deaths	Per Cent
Total number of cases.....	273	16	5.8
Total number of cases not operated upon.....	90	6	6.6
{ Refused operation.....	26	}	
{ Operation not advised.....	64		
Total number of cases operated upon.....	183	10	5.4
Delayed operation.....	164	7	4.2
Immediate operation.....	19	3	15.7

In an analysis of the cases in which no operation was carried out, and in which there were six hospital deaths, we find that three were admitted moribund, when no thought of operation could be entertained, and at autopsy all had stones in the common bile duct. Three others died cardiovascular deaths, one from coronary thrombosis, one with accompanying mental confusion and complete lack of ability to coöperate, the result of cerebral arteriosclerosis, and one from auricular fibrillation and circulatory failure. It becomes obvious that in three of these cases even the most enthusiastic advocate of immediate operation would have hesitated because of cardiovascular insufficiency, and had the three who were admitted moribund been subjected to urgent operation, would the

stones in the common bile duct have been overlooked? It does not appeal to us as sound surgical judgment to explore the common bile duct in the presence of acute infection in the gall-bladder. The stone in the common bile duct does not create an emergency in acute cholecystitis, as it must have been present in this site for a long time. Often the emergency could have been controlled with the stones still in situ in both gall-bladder and common duct.

TABLE II

## PATIENTS NOT OPERATED UPON

Total number of cases. . . . 90 Deaths 6—6.6 per cent  
26 were advised and refused operation  
3 were admitted moribund (at autopsy all had stones in the common bile duct).  
3 died cardiovascular deaths, and it was never possible to consider operation.

In an analysis of the cases submitted to operation, one must first of all define what is meant by delayed operation. By delayed operation we mean that the patient is in hospital sufficiently long to have sedatives administered and to restore an adequate balance of body fluids, and salts. This requires from twelve hours to much longer periods. During this time the clinician is given an opportunity to evaluate the progress of the disease, to assess the patient's physique, the history of previous illnesses and their sequelae, and to determine if there are associated disease processes or handicaps from which this patient was suffering prior to the onset of the acute cholecystitis. In other words, the patient who is admitted through the night is not sent to the operating room, but is sent to the ward.

In the group in which an immediate or precipitate operation was carried out, it might be said that in view of the fact that there were only nineteen such patients, our opinion is of little value. This criticism is sound and we are prepared to accept it. Nevertheless an analysis of these patients is interesting.

In this group there were nine errors in diagnosis, the erroneous diagnosis being either acute appendicitis, perforated duodenal ulcer, or acute hemorrhagic pan-

TABLE III

## PATIENTS SUBMITTED TO DELAYED OPERATION

Total number. . . . . 164 Deaths 7—4.2 per cent  
An analysis of the seven deaths reveals the following:  
1 died forty-eight hours postoperatively from anuria and pulmonary edema, the result of a uremic state.  
1 was the result of an error in judgment, where the edema which involved the hepatic colon was interpreted as a primary carcinoma of the colon, and a resection done. The patient died of peritonitis.  
1 died ten days after operation from an acute pancreatitis, the result of a stone in the ampulla of Vater which had been overlooked at the original operation.  
1 died one month after operation from the relentless progress of the associated acute haemorrhagic pancreatitis.  
1 died twelve days after operation from a pulmonary embolus.  
1 died from shock following a second operation. Following the first operation carried out in the presence of jaundice, this latter persisted, and with the thought that a stone was overlooked in the common duct, a second operation was carried out. No stones found, but shock caused death.  
1 died of peritonitis. Had previously had five laparotomies, and adhesions were terrific. It is presumed operative trauma to bowel explains the source of peritonitis.

creatitis. One was a patient mentally ill, in whom immediate operation was urged because of the difficulties presented by the mental state. Another was a doctor who was impressed with the necessity of urgent operation, and demanded that such be carried out. In this group there were thus eleven of nineteen cases in which operation was done for reasons other than a belief that the acute cholecystitis demanded urgent interference in order to save life. One patient was operated upon four and a half hours after the onset of pain, with a temperature of 101 and leucocyte count of 15,000. In this instance there was definite edema about the gall-bladder. Cultures made from the pericholecystic area, from the gall-bladder wall and from the lumen were sterile, both aerobic and anaerobic. In other words, this patient was suffering from an acute cholecystitis of non-bacterial origin, that is, from severe biliary colic. One is apt to lose sight of the fact that a severe biliary colic may be accompanied by fever and increased leucocyte count, and yet no bacterial infection demonstrable. In this group there were three deaths: one due to the progression of an acute pan-

creatitis; one to the progression of an acute pancreatitis following drainage of the gall-bladder (at autopsy stones were present in the common bile duct); and a third, a diabetic, admitted with general peritonitis, diagnosed as the result of a perforated appendix, at operation found to be due to perforation of the gall-bladder. This last patient died from general infection.

This emphasizes the fact that operative interference may have very little effect on the progression of acute pancreatitis. If one could be absolutely certain of the diagnosis of acute hemorrhagic pancreatitis, it is our impression that the patient would be better if operation were withheld. Furthermore, it again stresses the fact that in urgent operation on these patients, stones in the common bile duct may be overlooked. We all know how difficult it is to avoid this catastrophe in elective biliary surgery, and how much more difficult, to say nothing of how much more hazardous it becomes to the patient if one adds exploration of the common bile duct to an urgent operation which is primarily carried out to prevent death from acute cholecystitis.

TABLE IV

PATIENTS SUBMITTED TO IMMEDIATE OPERATION

Total number of cases.... 19 Deaths 3—15.7 per cent  
Analysis of Deaths

1. Progressive pancreatitis.
2. Progressive pancreatitis. Autopsy showed stone in the common bile duct.
3. Diabetic: perforated gall-bladder; general peritonitis.

It was of interest to separate from this entire group the patients who were operated upon by the staff of the First Division and the author's private patients, following the survey which terminated with the series up to January 1934. This gives us a group from January 1934 to July 1, 1939, of sixty-eight patients, with two deaths, a mortality of 2.5 per cent. Three of the patients refused operation, one of whom has since been operated upon successfully in another city, and two were not advised to be operated on. Their ages were 77 and 88 respectively, and both had associated serious cardiovascular disease. This leaves

sixty-three patients upon whom operation was carried out, and there were two deaths—an operative mortality of 2.5 per cent.

Six emergency operations were carried out. In four instances operation was done because of erroneous or doubtful diagnosis. Two cases, previously mentioned, were operated upon immediately on admission, the physician who insisted on immediate operation and the mentally ill patient whose emergency operation was undertaken because of aggravation of mental upset. One death only occurred in the six emergency operations, and this was in a diabetic patient who was admitted with a perforated gall-bladder, erroneously diagnosed as appendicitis, and who died of general peritonitis.

Two most interesting cases are included in this group of six emergency operations. In both the diagnosis was acute appendicitis. In one the abdomen was opened by a McBurney split muscle incision. The appendix was normal. On palpating through the incision one felt a large, tense, distended gall-bladder, which was responsible for the disability. The gridiron incision was closed and the patient was returned to bed. The acute cholecystitis subsided promptly, and three weeks later an elective cholecystectomy was carried out, from which the patient made an uninterrupted convalescence.

The second case was much more illuminating. The abdomen was opened by a paramedian incision, and again the appendix was found to be normal. On this occasion the incision was such that visualization of an acutely inflamed gall-bladder was possible. A greeny black necrotic area was seen in the fundus. This was protected by omentum, and in view of the fact that the patient was elderly, aged 77, had a previous coronary thrombosis, and possessed a seriously damaged cardiovascular mechanism, the abdomen was closed and the patient returned to bed. This patient was seen recently, suffering no disability whatever from his gall-bladder. He has fortunately had no further attacks of acute



cholecystitis, and, because of his serious cardiovascular handicap, elective operation has not been advised. Thus we have definite proof that a gangrenous cholecystitis is not necessarily followed by general peritonitis and is not inevitably fatal.

We were impressed by the group of patients treated conservatively without urgent operation on the gall-bladder. There were fifty-seven delayed operations, with one death—a mortality of 1.75 per cent. This patient died from anuria associated with acute pulmonary edema forty-eight hours postoperatively. It is interesting to note that in this group there were five cases of acute hemorrhagic pancreatitis; in none of them was an emergency operation carried out, and there were no deaths. Six, or 10.5 per cent of the patients had stones removed from the common bile duct when delayed operation was carried out. It being our belief that no exploration of the common bile duct should be carried out in the patients having urgent operation, six of these patients would still harbor serious biliary disease had they been submitted to urgent operation.

TABLE V  
SERIES JANUARY 1934 TO JULY 1939

		Deaths	Per Cent
Number of cases.....	68	2	2.5
No operation.....	5		
Emergency operation.....	6	1	16.4
Delayed operation.....	57	1	1.75
Included			
Acute pancreatitis 5 cases.			
Stone common duct 6 cases.....			

#### DISCUSSION

In the selection of the cases which we have analyzed, great care has been taken to make sure that the diagnosis was definitely established. In this group it becomes obvious that the only cases in which there was any question whatever were those in which no operation was car-

ried out. As we are particularly concerned in determining the wisdom of urgent or delayed operative therapy, this group lent a certain weight to the fact that urgent operation is not always necessary. Of the entire group of ninety patients who either refused or were not advised to be operated upon, there were only six deaths, and none of these six patients, we submit, would have been alive had urgent operation been carried out. That some of the remaining eighty-four patients not operated upon may ultimately die from acute cholecystitis is possible. In twenty-six instances, operation was advised and the patients refused. However, we have discharged our obligation to save life, and the patients did not die while under our care. This leaves fifty-eight patients in whom, for various reasons, operation was not advised, and if they succumb subsequently, it will be due to the frailty of human judgment, as their discharge without operation at the time they left our hospital we considered was in their best interests.

That acute cholecystitis should be considered as a parallel disease to acute appendicitis we cannot bring ourselves to believe. In this entire group there were only three cases of general peritonitis, and in the delayed group there were eleven patients who had a perforation of the gall-bladder with a pericholecystic abscess and no general peritonitis, none of whom succumbed to the original perforation nor to the later operation. This tremendous difference between the localization and the diffuseness of the inflammatory reaction as seen in acute cholecystitis and in acute appendicitis we suggest should of itself be sufficient to demand considering these two disease processes as presenting entirely dissimilar problems. We still are struggling in our surgical division with the problem of acute appendicitis. It is rare that the entire staff of the division is not in consultation over the problem which a patient is presenting following the perforation of an acute appendicitis, but it is indeed infrequent to find the staff distressed with the

difficulty of arriving at a decision as to the proper management of a case of acute cholecystitis. We cannot believe that acute cholecystitis in Toronto is any different from acute cholecystitis seen elsewhere. What, then, can explain our apparent placidity in the face of a serious disease? It must resolve itself entirely into a question of terminology. We believe that there are three distinct pathologic entities that in many of the reported publications are called acute cholecystitis, and thus confuse the real issue. We refer to: (1) biliary colic; (2) acute cholecystitis; and (3) acute cholangitis.

The criteria for the diagnosis of acute cholecystitis have in many publications been postulated as disease of the gall-bladder, accompanied by severe abdominal pain, an elevation of temperature and pulse rate, and an increased leucocyte count. No case of acute cholecystitis in our experience has ever occurred in which there was not obstruction of the cystic duct, either from stone or thick, tarry bile: hence these criteria may be fulfilled by biliary colic, entirely dissociated from any infection. In the last group of sixty-three operated patients, stones were present in the gall-bladder in fifty-six. As a result of this obstructive phenomenon, which we believe to be the basis of the acute cholecystitis, there is an inflammatory reaction characterized by edema, but it is not associated necessarily with infection. That this can occur we have proved by the case of a patient operated upon four and a half hours after admission, with a temperature of 101 and a leucocyte count of 15,000, in which exhaustive bacteriologic study of the material removed failed to reveal the presence of organisms.

Therefore many of the patients operated upon within the first forty-eight hours from the onset of the pain are really being operated upon for persistent biliary colic. That this procedure is unwise we do not suggest, but that it is necessary to save life we do not believe. That one can submit to operation within the first forty-eight hours a

very large percentage of patients suffering from severe and persistent biliary colic, with a very low operative mortality, is not surprising.

In our series of patients an analysis was made of the length of time between the onset of the symptoms and admission to hospital, and this was found to average six days. Because of the proximity of the colon, which at the end of six days is involved in the inflammatory process initiated by the biliary colic, in which the biophysical properties of both the colon and the gall-bladder are altered, infection becomes an additional hazard, which creates a greatly increased risk to life. That this infection may also spread to and involve the common bile duct by the edema with resultant jaundice, presents one of our great diagnostic difficulties. We must determine whether we are dealing with an acute infective cholecystitis, with or without cholangitis, or whether we are dealing with a cholangitis with or without an acute cholecystitis. We have found in an analysis of a former series of patients suffering from jaundice, that jaundice resulted from an acute cholecystitis more frequently than from a calculous obstruction of the common bile duct. In other words, we believe that if we have a palpable, tender mass in the right upper quadrant, accompanied by fever, leucocytosis and jaundice, but no chills, we are justified in assuming that the clinical picture is the result of an acute cholecystitis alone. If to this picture we add recurring chills, then we must assume that there is a superadded cholangitis. This latter complication is, fortunately, rare.

While, as outlined in the data presented, we are content to adopt a conservative attitude in the treatment of acute cholecystitis, we believe that an acute cholangitis is a disease of the greatest seriousness, and that drainage of the biliary apparatus should be established without undue delay. Effective drainage of the biliary apparatus cannot be achieved by a simple cholecystostomy: it must be accompanied by choledochotomy.

This conception of acute cholecystitis is forced upon us by the material with which we are confronted, namely an acute inflammatory process confined to the gall-bladder and accompanied by infection—the infection present because of the length of time that these patients are ill before being admitted to hospital. Such a diagnosis is represented by a patient who has suffered colicky pain of the biliary colic type, has a palpable mass in the right upper quadrant with an associated elevation of temperature and pulse rate, a leucocytosis and occasionally the presence of jaundice. We are quite conscious of our inability always to visualize accurately the degree and extent of the pathologic changes which are present in the gall-bladder. We have presented evidence, however, which suggests this is not so important as some authors would lead us to believe.

While we are willing to accept the criticism that our very limited experience with urgent operation in acute cholecystitis does not permit us to express an opinion that is of the slightest value regarding the merits of this type of therapy, we do feel that we are in a position to state that delayed operation is not so disastrous as it is often painted. The mortality of 5.8 per cent in the total group of 273 cases, in which the histories have been read and accepted for study by the author, we submit, is not forbidding. We have advanced evidence to show that even if a gangrenous patch be present on the gall-bladder, and the gall-bladder is left in situ, the patient does not necessarily die. This is of tremendous importance, because we are very conscious of the fact that the local pathologic lesion as viewed at operation cannot be predicted at all accurately, but if we believe, as there seems to be justification to do, that a gall-bladder which has reached the stage of gangrenous patches can subside so completely that the patient is able to carry on free from symptoms, we are given tremendous moral support and mental comfort in treating these cases conservatively.

The argument that a fair percentage of patients, when they recover from their acute infection, will refuse operation and will thus be in danger of subsequent catastrophe, is not in our opinion valid argument for urgent operation. We cannot force our opinion on an unwilling patient in acute cholecystitis any more than we can in any other disease in which he may choose a course of action at variance with that which we advise. Further, we recognize and accept the criticism that the economic time loss is much greater for the patient treated by the delayed, conservative therapy than for the patient submitted to an emergency operation, providing both patients recover. While this is true, if conservative management carries with it the slightest increased factor of safety, or makes possible a more adequate operation, such as exploration of the common bile duct with, when necessary, removal of stones, then the increased economic time loss should never be a factor in determining our treatment. The evidence presented suggests that delayed operation is safer and more adequate.

While in the experience of the surgeon specialist attached to a large general hospital, the problem of acute cholecystitis is ever present, it is not so with the occasional operator. While one would probably choose otherwise, we must face the fact that the occasional and often the very occasional operator is in our midst, in probably ever increasing numbers. Such operators—many are not surgeons—are probably more justified in their surgical endeavors when dealing with lesions which demand urgent operation in order to save life, than in any other phase of their surgical practice. As they depend to a large extent for their surgical judgment upon the writings and teachings of men attached to large clinics or teaching units, the current literature of recent years would lead them to believe that acute cholecystitis is a disease where urgent operation is demanded to save life. While the expert surgical technician, surrounded by all the facilities and biophysical aids of a large and

well-organized hospital, may successfully operate upon acute cholecystitis with a mortality which is not forbidding, does it seem reasonable that the occasional operator in a small hospital, in the middle of the night, can be placed in the same category? Under such conditions the physician-surgeon is suffering from fatigue, and often only indifferent assistance and anesthesia are available. The biophysical laboratory facilities are lacking, as is often the knowledge which would enable the operator to use them intelligently were they available. Surely the hazard which such a patient accepts is unjustifiable, in view of the data which have been presented here. Under such circumstances the biochemical imbalance should be restored by the administration of water, salt, glucose and blood! Pain and fatigue are overcome by sedatives, and heat applied to the abdomen. This treatment does not need to be persisted in indefinitely, but in our experience the clinical improvement is such that the emergency which was present at 2 o'clock in the morning is often not present twelve hours later. If, however, it should be considered wise to operate at this later time, all resources would be available, and the patient's general condition improved.

What, then, are the criteria which determine abandoning conservative therapy and instituting direct surgical attack? The most important single symptom is pain. If, following the restoration of the biochemical balance and local application of heat, the pain is persisting, despite the administration of what one would consider adequate doses of sedative, operation should be undertaken, even though the temperature, pulse rate and leucocyte count are not increasing. On the other hand, if pain is diminished, the patient is more comfortable, and the general appearance is improving, we need not be stampeded into direct surgical approach simply because the temperature and leucocyte count are increasing. If, on the other hand, there is an increase in the pulse rate, we must pause before continuing conservative plan of

management. In other words, the persistence of pain or a persistently maintained high or increasing pulse rate demands direct surgical attack as soon as the patient's biochemical balance is restored by means of the intravenous administration of water, salt and glucose.

When operation has to be undertaken at this time, the degree of edema not only in the gall-bladder wall, but in surrounding structures, with the accompanying increased vascularity, creates a problem in technical surgery which is at variance with those associated with chronic cholecystitis. An incision through the seromuscular coat of the gall-bladder will often permit, because of the edema of the gall-bladder wall, the shelling out of the mucous membrane from the seromuscular coat, very much as one shells a banana from the skin. If, on the other hand, this is not readily possible, the suggestion of partial cholecystectomy advocated by Harry Ritchie and William Estes, Jr.<sup>1</sup> is excellent. In this the gall-bladder is split from the fundus to the cystic duct. The major portion of it is excised, leaving the part attached to the liver intact. The mucous membrane from this area can be removed with a sharp bone curette, and then the remnant is oversewn to control the oozing. Such a procedure avoids, to the greatest possible extent, damage to the liver, and incidentally injury of the common bile duct. By this means one can safeguard the patient to the greatest possible degree. In the districts where operation must be undertaken by the occasional operator, the elapsed time which is necessary to restore biochemical balance permits, to the greatest degree possible, the marshalling of all the resources available, and as a result should work to the advantage of the patients.

#### CONCLUSIONS

1. An analysis of 273 cases of acute cholecystitis, with a mortality of 5.8 per cent, is presented.
2. Failure to differentiate between biliary colic, acute cholecystitis, and acute

cholangitis, has confused the statistical data presented in the literature.

3. Persistent biliary colic produces an acute cholecystitis, accompanied by increased temperature, pulse rate and leucocytosis, but not necessarily accompanied by infection until several days elapse.

4. Average duration of symptoms in our cases was six days prior to admission to the hospital.

5. Acute cholecystitis with infection presents a history of biliary colic, a palpable, tender mass in the right upper quadrant, increased temperature and pulse rate, leucocytosis and occasional jaundice.

6. Such a case does not demand urgent operation to save life.

7. If after restoring biochemical balance, there is undiminished pain despite adequate sedation, or if pulse rate rises or

remains persistently high, direct surgical attack is indicated.

8. In 10.5 per cent of the patients operated on after conservative treatment stone was removed from common bile duct. Exploration of common bile duct is inadvisable coincident with emergency operation.

9. The delay necessary to restore biochemical balance enables the occasional operator to marshall all available resources.

10. While our experience with urgent operation is very limited, evidence is presented of 164 delayed operations with a mortality of 4.2 per cent, leading us to conclude that in such a serious disease, this mortality is not forbidding.

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# ACUTE PANCREATITIS\*

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**A**CUTE pancreatitis is a rare disease. At the Henry Ford Hospital, there has been but one operation performed for acute pancreatitis for each 10,000 admissions. It is obvious, therefore, that opportunities for an extensive personal experience with this disease are limited. This fact is reflected in current textbooks in surgery whose authors have been content to follow Moynihan<sup>1</sup> in his dramatic description of the disease and in his advice regarding immediate surgical intervention. It is with these two predominately practical phases of the condition that this presentation will deal.

Brief reference to the salient points of the anatomy, embryology, and physiology of the pancreas is essential because of their bearing on the pathology and treatment of inflammatory affections of the gland.

*Embryology.* The pancreas, like the liver, develops from the duodenal portion of the foregut. Pancreatic buds grow in both the ventral and dorsal mesenteries. The ventral bud from which develops the head of the organ has a close connection with the hepatic bud which accounts for the common opening of the main pancreatic duct of Wirsung and the bile ducts. The dorsal bud gives origin to the body of the pancreas and the accessory duct of Santorini. Usually the two pancreatic ducts fuse, with obliteration of the terminal position of the duct of Santorini, but occasionally the latter persists and opens into the duodenum about  $\frac{1}{2}$  inch caudal to the common opening of the bile duct and duct of Wirsung. Likewise, the common bile duct and duct of Wirsung may open separately into the duodenum.

*Anatomy.* The pancreas is an entirely retroperitoneal organ, extending trans-

versely across the posterior abdominal wall from the concavity of the duodenum to the hilum of the spleen. The surface marking is the transpyloric plane which is a line drawn at right angles to the long axis of the body at the midpoint between the umbilicus and the xiphi sternum. This corresponds to the upper border of the first lumbar vertebrae posteriorly and also marks the course of the splenic artery which runs along the upper border of the pancreas and provides its main blood supply. The peritoneum of the posterior wall of the lesser peritoneal sac provides a covering for the anterior surfaces of the gland. At the lower border of the pancreas the anterior and posterior layers of the mesocolon separate to provide a peritoneal covering for the transverse colon and in this potential space products of inflammatory diseases may collect to form pseudocysts and abscesses. Also, the lesser peritoneal cavity may be the site of similar formations when the peritoneal covering is destroyed, or injured, for the foramen of Winslow is usually closed by adhesions early in inflammatory diseases or trauma of the pancreas.

*Physiology.* The pancreas, in addition to its anti-diabetic internal secretion, insulin, pours important juices into the duodenum through the duct of Wirsung. The principal pancreatic ferments are the protein-splitting trypsin, the starch-splitting amylase and the fat-splitting lipase.

## ETIOLOGY

The most commonly accepted explanation of the origin of pancreatitis is that bile enters the pancreatic ducts, activates the trypsin of the pancreatic juice, thereby producing autolysis of the gland with re-

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sulting hemorrhage and necrosis. This theory receives support both from occasional autopsy findings of obturation of the bile papillae in fatal cases of acute pancreatitis and from experimental production of the disease in animals by introduction of bile into the pancreatic ducts.

The validity of this theory has been questioned because in only about 10 per cent of patients is it possible to demonstrate anatomically a common channel between the pancreatic and common bile ducts when the bile papilla is occluded by a calculus or by spasm of its sphincter.

Recently Rich and Duff<sup>2</sup> have presented evidence that in some cases metaplasia of the pancreatic ducts results in obstruction, dilatation, and rupture of the gland acini with liberation of trypsin and ultimate autodigestion.

The infective theory long dormant has again received attention following the work of Dragstedt.<sup>3</sup> Spread of infection via the lymphatic system is suggested by the frequency with which chronic pancreatitis is found in conjunction with advanced gall-bladder disease, but if this were a common route of infection the association of acute pancreatitis and acute cholecystitis should be more frequent than it is. In a recent, and as yet unpublished series of cases of acute cholecystitis studied at the Henry Ford Hospital, only two were complicated by acute pancreatitis. Blood-borne infection is a possibility clearly indicated by the occasional development of acute pancreatitis in mumps. Furthermore, the clinical picture in fulminating pancreatitis is not unlike that of any other overwhelming infection.

#### PATHOLOGY

It is generally conceded that changes in the gland are due to autolysis from activation of the proteolytic ferment trypsin. The amount of damage to the gland varies greatly and determines the clinical picture.

A simple classification which recognizes only three stages of a process which may merge imperceptibly from one to another

is that of simple edema, acute hemorrhagic pancreatitis, and pancreatic abscesses or pseudo-cysts. Mild degrees of involvement result in simple enlargement and edema of the organ resembling the condition found in chronic pancreatitis except that in the former the gland is much softer. This stage is known clinically as simple edema of the pancreas or acute interstitial pancreatitis and is considered by some observers<sup>4</sup> to be a separate clinical entity, and not merely the beginning of a pathologic process which may go on to complete disruption of the gland.

When the condition is progressive and actual destruction of the gland takes place, we have the stage known as acute hemorrhagic pancreatitis or acute pancreatic necrosis. The involvement can include the whole gland or may be limited to the head, the body, or the tail. The degree of destruction of pancreatic tissue also varies greatly from disruption of isolated lobules to necrosis of practically the whole gland. The amount of hemorrhage depends on the degree of destruction and blood stained fluid collects either in the peritoneal cavity or is disseminated in the retroperitoneal tissues. Liberation of the fat-splitting enzyme, lipase, results in the phenomenon of fat necrosis. These tubercle-like areas in the omentum and mesenteries are diagnostic of the disease and result from the breaking down of fat molecules into fatty acid and glycerine with absorption of the latter and combination of the former with calcium to form the characteristic plaques.

Pseudo-cysts or abscesses are the final stage of the pathologic process. Pseudo-cysts are collections of fluid and products of pancreatic necrosis and collect either in the lesser peritoneal cavity which is usually closed at the foramen of Winslow by adhesions early in the disease, or between the leaves of the transverse mesocolon. Abscesses are either infected localized areas of necrosis or infected pseudo-cysts. This stage is generally found in patients who were treated conservatively either deliberately or because the correct diagnosis was

not made. Recovery is usually prompt after surgical evacuation. The observation that patients who developed this complication usually recovered has formed the basis for the non-operative treatment of acute pancreatitis.

#### CLINICAL FEATURES

Pancreatitis is a disease of middle age; in our own cases<sup>5</sup> one-third of the patients were between the ages of 40 and 50 and one-half of them between the ages of 40 and 60. Obesity is common. Women are apparently more commonly affected than men, in the proportion of 3 to 2. Fully 60 per cent of patients give a history of previous gastrointestinal disease, and about one-half of them will admit to a previous similar attack of pain though of much less severity.

The classical description of acute pancreatitis is that of a patient complaining of agonizing, upper abdominal pain and presenting signs of pronounced shock and circulatory collapse. However, study of groups of cases shows that the foregoing clinical picture is rarely seen and that the majority of even severe cases presents much milder symptoms.

*Pain*, the outstanding symptom, is usually severe and persistent. It is located in the mid-epigastrium or just to the right of the midline, thereby resembling acute cholecystitis, but when the tail of the organ is involved, it may be to the left of the midline. Referred pain may be complained of in the back or in the shoulder blades. Rarely the irritating products of pancreatic disruption may trickle out through the foramen of Winslow and pass down the right colonic gutter to give rise to signs simulating acute appendicitis.

*Nausea and vomiting* are constant symptoms, often initiating the attack and continuing throughout the acute stage of the disease.

*Shock*. This symptom which receives such prominence in textbook descriptions of the disease is of rare occurrence in our experience at this clinic—an observation

that has been confirmed by others, notably Elman.<sup>4</sup> Certainly its absence has no diagnostic significance.

*Cyanosis*. In contrast to the observations of Halsted and Moynihan, cyanosis is rarely seen except in fulminating cases.

*Jaundice*. A definite icteric tint is present in about one-fourth of the patients.

*Localized Areas of Skin Discoloration*. Bluish discoloration of the skin in the flank (Grey-Turner's sign) or around the umbilicus (Cullen's sign<sup>6</sup>) may be observed in from 10 to 15 per cent of patients suffering from acute pancreatitis. This discoloration is due to retroperitoneal dissemination of blood from the disintegrating pancreas. It gives valuable confirmatory evidence, the value of which has been expressed in a previous communication.<sup>6</sup>

*Pulse and Blood Pressure Readings*. In a series of twenty-six cases of acute pancreatitis proved by operation at the Henry Ford Hospital,<sup>5</sup> the maximum pulse rate was under 100 in 40 per cent of the patients and over 120 in only 125 per cent. The systolic blood pressure was below 100 in only 3.8 per cent of the patients.

*Temperature*. The temperature is usually moderately elevated. Readings above 102°F. are rare and a normal or subnormal temperature is not uncommon.

*Abdominal Distention*. There is usually moderate generalized distention due to ileus of the colon. This distention may be pronounced in severe cases and not infrequently is confined to the upper abdomen.

*Tenderness*. The area of maximum tenderness corresponds in general to the location of the pain and is elicited in the mid-epigastrium in two-thirds of the patients. In some instances it is possible to outline the swollen and indurated pancreas on deep palpation, and after subsidence of acute symptoms, the development of pseudo-cysts and abscesses may be detected readily.

*Muscle Spasm*. Because of the depth at which the organ lies and its protection by other viscera, muscular rigidity is minimal. It may be entirely absent, but usually both



rectus muscles above the umbilicus are on guard.

#### LABORATORY INVESTIGATIONS

In contrast to the clinical features which have much in common with other acute abdominal affections, the laboratory investigations in acute pancreatitis are of such significance that positive findings confirm the diagnosis in suspected cases.

*Blood Diastase Estimation.* The diastase content of both blood and urine is increased in the early acute stage of the disease.<sup>7</sup> It should be emphasized that high readings may be obtained only during the first two or three days of the attack and that normal readings may be found before the attack subsides. Blood diastase estimations are more reliable than urine estimations. Normal readings with the Somogyi test vary from 80 to 150. Using the Meyer's test, readings above 15 are suggestive, and above 20 are definitely indicative of acute pancreatitis.

*Leucocytosis.* The white blood count is almost invariably elevated and in general the count is higher than that obtained in acute cholecystitis and perforated peptic ulcer—the condition with which acute pancreatitis is most likely to be confused. In our own cases, almost one-half of the patients had a leucocytosis of over 20,000 per cm. mm. The average polymorphonuclear count for the same series was 88.6 per cent.

*Blood Sugar Estimation.* Contrary to what might be expected, normal blood sugar readings are the rule.

*Urinalysis.* The toxicity of acute pancreatitis is emphasized by the consistent finding of albuminuria. Evidence of glucose, however, is rare.

*Icteric Index.* Readings are seldom high, but frequently reveal evidence of subclinical jaundice.

#### DIAGNOSIS

The diagnosis of acute pancreatitis is frequently missed because the observer fails to consider the disease as a possibility.

The typical patient is obese, middle-aged, and suffering from an acute abdominal condition which leads the medical attendant to consider a diagnosis of gallstone colic with or without acute cholecystitis. Further confirmation of this opinion is gained from a history of previous gallstone disease is fully 60 per cent of the patients.

Pancreatitis should be suspected when the pain and vomiting is persistent and more severe than is usual in acute cholecystitis. Tenderness is likely to be in the midline and even to the left when the pancreas is involved. A leucocytosis of over 20,000 per cu. mm. with high polymorphonuclear count should arouse suspicion of pancreatic involvement. Definite diagnostic findings such as a palpable mass in the epigastrium or a positive Cullen's or Grey-Turner's<sup>6</sup> sign of skin discoloration are unfortunately present in only 10 per cent of the patients. A blood diastase estimation made in all patients with the foregoing signs will give a high reading in a surprising number of instances and provide positive diagnostic evidence of acute pancreatitis.

#### DIFFERENTIAL DIAGNOSIS

Before discussing the differential diagnosis, it is well to emphasize that the present day diagnosis of acute pancreatitis is made by:

1. Consideration of it as a possibility in all acute upper abdominal conditions.

2. Employment of blood diastase estimations in all suspected cases. This test can be run in a few hours and elevations above normal are of definite confirmatory value.

3. Use of the flat abdominal x-ray plate to rule out other conditions such as intestinal obstruction, perforated peptic ulcer, etc.,

A few points of distinction between acute pancreatitis and the abdominal emergencies with which it is commonly confused will now be considered.

*Acute cholecystitis* is a condition which gives the chief difficulty, but in pancreatitis, both pain and vomiting are more severe, the leucocytosis is higher, and tenderness is in the mid-epigastrium or to the left of the midline. It is helpful to remember that, in general, acute cholecystitis tends to subside after seventy-two hours and that if acute symptoms persist after this time, a complication such as empyema, gangrene, perforation, stone in the common duct, or pancreatitis has arisen.

*Perforated peptic ulcers*, especially pinpoint openings with minimal leakage, may give rise to confusion because of the severity of the pain, but muscular rigidity is pronounced, there is little or no distention and the leucocyte count usually remains below 20,000. Furthermore, a flat x-ray plate of the abdomen will usually show free air in the peritoneal cavity.

*Acute Intestinal Obstruction.* Continuous vomiting and distention often lead to diagnosis of intestinal obstruction, but a flat plate of the abdomen fails to reveal characteristic dilated loop of the small intestine.

*Coronary Occlusion.* Profound shock and extreme circulatory collapse seen in fulminating cases suggest occlusion of the coronary vessels, but in the latter, the distribution of pain and the absence of local tenderness should lead the observer to consider the advisability of obtaining a diagnostic electrocardiogram.

#### TREATMENT

The advice of Moynihan<sup>1</sup> regarding immediate operation in acute pancreatitis has been followed for many years. There is, however, an ever increasing number of surgeons<sup>8,9,10,11,12</sup> who not only question the value of early operation, but advise against this practice. It is significant that in most instances the decision to sponsor conservative treatment has arisen from a study of patients treated by immediate operation.

The author identifies himself with the group that advocates expectant treatment.

This conclusion was reached after a review of the results of immediate operation in twenty-six patients treated at the Henry Ford Hospital.<sup>5</sup> The finding of a mortality rate of 46.2 per cent in patients so treated was not out of line with reports from other clinics. However, one point in the analysis attracted our attention, and that was the observation that, in 75 per cent of the deaths, the average duration of life was only twenty-one hours. This revelation demanded a revision of our methods of management of acute pancreatitis, resulting in our adoption of the conservative treatment. This change has given us splendid results, for, of sixteen patients so treated, all but one have recovered—a mortality rate of only 6.3 per cent.

The advocates of immediate operation base their contentions upon the theory that the products of pancreatic necrosis are extremely toxic and that their evacuation is essential for the prolongation of life. This theory has been perpetuated because death in the fulminating cases has been attributed to absorption of the end products of pancreatic disruption. Against this theory may be cited the work of Whipple<sup>13</sup> who showed in 1913 that the peritoneal exudate in acute hemorrhagic pancreatitis was innocuous when injected into the veins or peritoneal cavities of animals. Furthermore, cases which have not been diagnosed and go on to abscess or pseudo-cyst formation usually recover after surgical drainage.

The opponents of immediate operation believe that operation not only will not benefit the severe cases but may turn the tide against them, a belief that receives some support from the observation that the duration of life after operation in fatal cases is frequently only a matter of hours.

The greatest drawback to the non-operative method of treatment is difficulty in arriving at the correct diagnosis, for it is obviously dangerous to delay operation if the symptoms are caused by a perforated peptic ulcer or intestinal obstruction. Blood diastase estimations are of such

diagnostic value that few errors will arise if this test is utilized in all cases of doubt. The decision to adopt conservative treatment in any case of pancreatitis should be made only after all reasonable doubts regarding the diagnosis are removed, for if there is any question, operation should not be delayed. Furthermore, just because the expectant treatment is instituted, it does not mean that good surgical judgment should not prevail during the full time that the patient is under observation. For example, a distended gall-bladder should not remain undrained because the surgeon is convinced that a coexisting acute pancreatitis will do better under conservative treatment. Abscesses and pseudo-cysts developing in the region of the pancreas require drainage in accordance with good surgical practice.

If operation is deemed necessary for any reason during the acute stage, it should be performed under local anesthesia because of the imminence of circulatory collapse. Operative procedures should be minimal whether the surgical attack is deliberate, or laparotomy has been performed on the basis of an erroneous diagnosis. The pancreas may be exposed by entering the lesser peritoneal cavity through an avascular area in either the gastrohepatic or the gastrocolic omentum. There is nothing to be gained by incising the peritoneum on the anterior surface of the pancreas because the gland is not possessed of a capsule and thus cannot be decompressed. Furthermore, serious hemorrhage may follow this dangerous practice. All that is necessary, is the placing of Penrose drains in the lesser peritoneal cavity. The biliary tract should be disturbed only if the gall-bladder is distended, and even then cholecystostomy is the operation of choice.

With a decision against operation, adequate supportive measures are indicated. Pain should be relieved by full doses of morphine, and shock should be treated by intravenous saline, and glucose and blood to aid the failing circulation. Continuous suction through a nasal catheter will

abolish distressing vomiting. Distention may be alleviated by continuous hot stupes and a rectal tube, with the addition of prostigmin and pitressin in cases unrelieved by simple measures. Food and fluid by mouth are best withheld until the acute stage has passed. Fluid balance is maintained by adequate intravenous and subcutaneous injections of normal saline. A minimum of 3,000 c.c. daily is required and more if there is much loss from the stomach tube. A good practical rule to follow is to administer sufficient fluid to insure a urinary output of at least 1,000 c.c. daily.

Under the foregoing régime, one may expect a subsidence of the acute symptoms in four or five days. The temperature and pulse usually return to normal limits before the leucocyte count comes down. Persistence of the leucocytosis with a return of the fever and temperature elevation should lead the surgeon to suspect abscess or pseudo-cyst formation as evidenced by the development of a mass in the epigastrium.

#### SUMMARY AND CONCLUSIONS

1. Acute pancreatitis is a rare disease.
2. The most commonly accepted theory of etiology is that based on the activation of trypsin by reflex of bile into the pancreatic ducts.
3. The disease is infrequently diagnosed largely because the observer fails to consider it as a possibility in acute upper abdominal affections.
4. The value of blood diastase estimations as a diagnostic procedure is stressed.
5. Expectant treatment is advocated on the basis of a comparison of methods at the Henry Ford Hospital. A mortality rate of 46.2 per cent occurred in twenty-six patients treated by immediate operation, while in sixteen patients treated conservatively, the mortality was only 6.3 per cent.

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DISCREPANCIES in Hindoo accounts of human anatomy as compared with modern knowledge are probably due not to lack of observation, but to the fact that dissections were made on the bodies of children of less than two years, since older children and adults were cremated.

# DIVERTICULITIS

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66 **L**EF T-SIDED appendicitis" is a term frequently used in describing diverticulitis. When diverticula of the distal descending portion of the colon and the sigmoid become the site of an inflammatory process, there occur local tenderness and muscular rigidity; often a mass can be palpated in the lower left abdominal quadrant; the temperature of the body is elevated and leucocytosis usually is present.

Diverticulitis differs from other inflammatory disease of the intestine in that it rarely occurs before the fourth or fifth decade of life. The process is often mistaken for malignancy. During the past decade, surgeons have learned how to differentiate it from neoplastic processes largely on the basis of the patient's history. In those cases in which doubt exists, the service that may be rendered by the roentgenologist is of greatest value.

It is of interest that literally dozens of diverticula may be present in the colon throughout life without producing symptoms or disturbance of function. Only recently, during necropsy at The Mayo Clinic, a colon was removed from the body of a male patient 78 years of age, who had succumbed to coronary disease. Several hundred diverticula were present in the colon in question, extending from the cecum to the upper portion of the rectum. For thirty years prior to this patient's death he had had interval examinations at the clinic, but in no instance did he complain of gastrointestinal disorder.

## DEVELOPMENT OF DIVERTICULA

The method of formation of intestinal diverticula, although not known exactly, is thought by the majority of observers to be herniation of the mucosa to a subserous

position through the muscular layers of the intestinal wall. Such herniations are thought to occur at sites of least resistance, and so far as can be ascertained, these sites are at or near the openings through which the blood vessels penetrate the wall of the bowel.

Edwards' recent (1936) exhaustive review corroborates the aforementioned view. He points out that the vascular pattern of blood supply to the intestine is constant in that the vessels arise from main trunks in pairs and penetrate the wall of the bowel. As a pair of diverticula enlarge, one diverticulum encroaches upon the other to such extent that the inner wall of each becomes destroyed by pressure; thus, two diverticula are converted into one. Edwards further emphasizes that diverticula almost invariably originate on the mesenteric border, and that an anomalous vessel is usually present at the same site. Although all observers do not fully agree with the idea that acquired diverticula arise from herniation of the mucosa through the wall of the intestine to a subserous position and at the site of vascular entrance into the intestinal wall, nevertheless, the consensus at present is definitely in favor of this view.

The mechanism of formation of diverticula seems logically explained as follows: during the period of contractions, the small vascular openings in the wall of the bowel naturally become smaller, while the opposite is true when relaxation of the intestinal segment takes place. If contraction of two portions of bowel occurs with a relaxed segment between them, a bit of the mucosa may be pushed out through the enlarged vascular opening. In some diverticula, Edwards has shown that the thickening of the muscular coats

may form a collar-band, thus producing a sort of valve.

If diverticula are found in one organ, it is not uncommon to find them in many organs; the condition has been observed in the duodenum, jejunum, colon and urinary bladder of the same patient. It is important to keep this tendency in mind.

#### SYMPTOMATOLOGY

I am of the opinion that diverticula of the duodenum and jejunum, although they are not uncommon, rarely produce clinical symptoms. Roentgenologists not infrequently report finding a duodenal diverticulum during the process of gastric roentgenoscopic study. Jejunal diverticula are often multiple and occasionally are thought to give rise to a marked "rumbling" soon after the ingestion of food. When diverticula of the small intestine are deemed to require surgical treatment, one of two procedures should be carried out: excision or segmental resection.

By far the most common and most interesting diverticulum of the ileum is the Meckel type. Often this anomaly is found during the course of an abdominal operation that is being carried out for relief of some other condition. It has been my practice to leave such lesions undisturbed if they are an incidental finding and particularly if the diverticulum has a wide neck so that it may empty freely. Meckel's diverticulum has become a clinical entity of greater importance since the discovery was made that occasionally it is the site of mucosal ulceration. The presence of a small amount of gastric mucosa is often found to be responsible for the ulceration; thus, the lesion is indeed similar to a true peptic ulcer.

In the cases of Meckel's diverticulum in which I have performed operation, the outstanding symptoms were intermittent cramp-like pain in the region of the umbilicus and the passage of blood per rectum. A most interesting and instructive case involved a female child 11 years of age, who since birth had passed blood per rec-

tum at frequent intervals. She had the appearance of being undernourished and anemic and was small for her age. A diagnosis of Meckel's diverticulum was made and at operation a diverticulum 66 cm. in length was found in the ileum. In size it was almost equal to the ileum, with which it had a common mesentery. In the distal tip of the diverticulum, an indurated region could be felt; this proved to be an ulcer. Resection would have entailed removal of a segment of ileum equal to the length of the diverticulum itself; since the patient's condition was precarious, anastomosis was made between the intestine and the diverticulum with the idea that more free drainage of the anomaly might bring about healing of the ulcer and sufficient improvement in the patient's condition to warrant resection at a later date. The immediate postoperative convalescence was without incident until the seventh postoperative day, at which time the child contracted pneumonia. She succumbed a few days later. The specimen removed at the time of necropsy showed the ulcer to be the result of the presence of gastric mucosa.

Another important consideration in dealing with Meckel's diverticulum is the possibility that malignancy may develop in the site of gastric mucosa. Such neoplasms have the characteristics of gastric cancer.

#### DIAGNOSIS

The diagnosis of diverticulum of the Meckel type rarely has been made roentgenologically, a fact that is easily understandable when it is considered that the opening into the diverticulum may be small, thus making the pouch difficult if not impossible to fill with opaque media. Only on two occasions has Weber been able to visualize the presence of Meckel's diverticulum. Both of the patients concerned had symptoms which prompted the clinician to emphasize the need of careful search for such a lesion during roentgenologic study of the small intestine.

Diverticula of the colon warrant more discussion than do lesions of similar character in other segments of the intestine, because (1) they are far more common, and (2) more frequently they become the site of inflammatory disease, than do other intestinal anomalies. Occasionally, both a malignant process and diverticulitis are found in the same segment of the intestine, but this finding is rare. Diverticula, so far as is known, are not the precursors of cancer.

The presence of diverticula in the right half of the colon is comparatively rare, and rarer still is diverticulitis in the proximal portion of the large intestine. Diverticulitis and diverticulosis are found more commonly in the descending colon and the sigmoid than elsewhere.

When diverticulitis occurs in a portion of the left half of the colon, the signs and symptoms of an acute inflammatory process are present. The diagnosis of diverticulitis of a portion of the left side of the colon or sigmoid is no longer the difficult problem it was two or three decades ago. Signs of inflammatory disease of acute or subacute nature in the left abdominal quadrant of persons of middle age at present suggest the possibility of diverticulitis. The patient's clinical history is of great importance, because a differential diagnosis between malignancy and diverticulitis is the problem to be solved. Bleeding from the bowel is an extremely rare accompaniment of diverticulitis, whereas it is an outstanding symptom of carcinoma of the colon. Constipation of increasing severity may be present in both conditions, but that type which is associated with diverticulitis is often more acute than other types. Finally, the signs of an acute infectious process favor a diagnosis of diverticulitis unless there is a history of long standing suggesting the presence of a malignant process which may have perforated. When roentgenologic studies of the colon of a patient who has diverticulitis are made, the characteristic observation is usually the presence of uninvolved diver-

ticula proximal and distal to the filling defect. The latter have a serrated pattern, whereas if carcinoma is present, the characteristic defect is more clear-cut and the proximal and distal limits of the disease have, in the roentgenogram, a concave or crescent-like appearance and, as a rule, no diverticula are present.

#### TREATMENT

The care of patients with diverticula in the proximal portions of the intestinal tract has been discussed. Diverticulitis is of more frequent occurrence in the more distal segments of the alimentary canal. The treatment of diverticulitis is first of all a medical problem. Once the diagnosis is made, the patient should be hospitalized, and should ingest a liquid or nonresidue diet. Warm, massive stupes should be applied to the abdomen. Rectal irrigations, using warm saline solution, are often of great benefit. The use of belladonna is frequently of aid in relaxing, at least partially, the spasm that is present at or near the site of the disease. If, after eight to twelve days, definite improvement is not in evidence, such as abatement of the signs of inflammation and release of the obstruction, surgical interference would seem to be in order. In such cases, my practice has been to perform colostomy in a proximal, nondiseased segment of the colon. By deflecting the fecal current through the stoma thus formed, the disease may show marked regress within a few weeks. In cases in which colostomy is deemed advisable, it is usually a judicious plan not to attempt closure of the artificial stoma for at least twelve months, even though roentgenographically the site of the obstruction may show marked improvement. In some instances the patients have insisted that closure of the colonic stoma be carried out within a few weeks after its establishment. In many of such cases it has been my experience that a flare-up of the process will occur, requiring reestablishment of the colonic stoma.

If, after the previously described program has been given a fair trial, it is found that the diseased segment of bowel remains obstructed or nearly so, segmental resection is in order. Such a procedure may be carried out with end-to-end anastomosis, or an extraperitoneal operation may be performed. The latter procedure will require closure of two artificial colonic stomas, but for debilitated patients this often seems the safer plan.

Perforation of colonic diverticula with formation of abscess is best managed by allowing sufficient time to elapse for complete localization to the site, after which drainage of the surrounding abscess is usually necessary. This complication sometimes is responsible for the formation of a small colonic fistula which may close spontaneously. If, after four to six months, healing has not occurred, it has been my practice to perform colostomy in an uninvolved segment of intestine well above, or proximal to, the fistula. Here again, deflection of the fecal current frequently allows the fistula to close spontaneously. But should the fistula persist, one of two operative procedures are in order: closure of the fistula, or segmental resection, depending on the extent of the diverticulitis.

Perforation of a colonic diverticulum into the urinary bladder, according to my experience, almost invariably necessitates resection of the diseased colonic segment and closure of the opening in the bladder. In cases of this nature, I have found it prudent to carry out the procedure in stages, the first being colostomy, usually in the transverse colon, which is followed in six to eight weeks by resection of the affected portion of the bowel. Marked induration of a considerable portion of the wall of the bladder is present in association with the majority of enterovesical fistulas, and the presence of the induration necessitates wide excision. A suprapubic cystic stoma should be established and allowed to function for from three to five weeks, after which withdrawal of the catheter will bring about rapid healing of the urinary sinus.

It is well to emphasize again that a diverticulum of the colon may be associated with carcinoma, but that it is not a precursor of a malignant process and, therefore, a trial of conservative treatment is justifiable; if satisfactory results do not follow this method of attention, a more radical procedure is indicated, which is to say, resection is advisable.





# THE DIAGNOSIS AND TREATMENT OF SMALL BOWEL OBSTRUCTION\*

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## INTRODUCTION

UNTIL a few years ago, it was generally admitted that there had been very little progress in reducing the mortality of acute intestinal obstruction. Besides the paraoral administration of fluid and electrolytes, the treatment consisted chiefly of enterostomy with or without release or removal of the obstructing mechanism. The average mortality from these surgical procedures was 40 to 100 per cent depending upon the duration and nature of the obstructing lesion, the condition of the patient, and the surgical procedure performed (Shelley, Vidgoff, Cornell, Koslin, Colp, van Beuren and Smith, Wangenstein, Christopher and Jennings).

It seems that in past years enterostomy was used in the treatment of acute mechanical and paralytic ileus of the small bowel because no other more effective treatment was known. Within the last ten to fifteen years, however, medical measures have replaced the surgical treatment of acute dilatation of the stomach and paralytic ileus of the small bowel. The medical treatment has consisted of gastric lavage, spinal anesthesia, pituitary extract, morphine, intravenous saline and glucose, rectal tubes, etc. (Shelley). Of these gastric lavage with or without siphonage or constant suction has proved most effective (Janeke, Woolsey, Ramona and Rey, Ward, Bartlett, Wangenstein).

In 1931, Wangenstein was the first to suggest and use constant suction applied to an indwelling duodenal catheter in the treatment of acute mechanical ileus. Since then his ideas regarding the therapeutic problem in intestinal obstruction have been generally accepted. The purpose of this

paper is to discuss the use of siphonage drainage in certain cases of ileus and to review the present methods of diagnosis and treatment of acute obstructions of the small bowel as carried out at the University of Minnesota Hospitals.

## DIAGNOSIS OF ACUTE INTESTINAL OBSTRUCTION

The whole problem of ileus resolves itself into a differentiation between (1) simple and strangulating obstructions and (2) acute obstruction of large and small bowel. By simple ileus is meant one on a mechanical or neurogenic (spastic or paralytic) basis. By strangulating obstruction is meant one in which the blood supply, either arterial or venous, to the gut has been compromised.

### 1. *Acute Obstruction of the Small Bowel.*

The first step in the treatment of acute obstruction of the small bowel is a carefully taken and carefully evaluated history. The patient complains of intermittent, crampy, colicky pain; nausea and vomiting. On physical examination, the abdomen is found to be distended. The presence of abdominal scars and hernia should be noted. Peristalsis may be visible through the abdominal wall. The presence or absence of rebound tenderness should be ascertained by palpating the abdomen. On auscultation of the abdomen with the stethoscope, the presence of borborygmi should be determined as well as whether the intestinal noises are most intense at the height of abdominal pain.

Determination of the values for the blood chlorides, urea nitrogen and carbon dioxide combining power of the blood gives confirmatory evidence of small bowel obstruction, in that a hypochloremia,

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alkalosis and elevated urea nitrogen are usually present, especially if the obstruction is high in the intestinal tract. The most valuable of the laboratory aids is the x-ray film of the abdomen. It should be emphasized, however, that the x-ray pictures unless viewed in the light of the clinical and physical findings may be more misleading than helpful. All that the roentgenograms will show is (a) whether there is an obstruction present; (b) whether it is complete or partial; and (c) whether the large or small bowel is involved. Also they will help to determine the position of the indwelling duodenal tube and any increase or decrease in the amount of intestinal distention. They will not tell whether the obstruction is paralytic, mechanical or strangulating in nature, which is of paramount importance in the rational treatment of ileus. One must differentiate these various forms of obstruction by means of the clinical findings. One distinguishes mechanical from paralytic obstruction by the absence of intestinal noises in the latter condition upon auscultating the abdomen. In strangulation obstructions, the abdomen is more tender, rebound tenderness as well as intestinal colic may be present. Shock supervenes sooner in strangulating than in mechanical ileus.

2. *Colonic Obstruction.* Distinction must be made between obstructions of the large and small bowel. In cases of colonic obstruction, the patient complains of gas pains, cramps, diarrhea or constipation, blood in stools, weight loss. Vomiting is not a prominent feature until late in the disease. On physical examination one finds varying degrees of abdominal distention depending upon the duration and acuteness of the obstruction. A scout film of the abdomen will show a distended colon with little if any distention of the small bowel. This is thought to be due to the competency of the ileocecal sphincter, but how often this sphincter is competent in colonic obstruction is not known. A barium enema may reveal the obstructing lesion, but too much importance should not be attached

to a negative report. If one inserts a gastric tube, one obtains only clear juice from the stomach. This is an important differential sign, for in small bowel ileus one obtains "feculent regurgitation" upon aspirating the stomach. Also in contradistinction to cases of small bowel obstruction, study of the blood chemistry in colonic obstruction is of little value.

#### TREATMENT OF ACUTE OBSTRUCTION OF THE SMALL BOWEL

*Conservative Therapy.* Paralytic ileus and partial mechanical ileus on an adhesive basis are ideally treated by siphonage drainage. Strangulating obstruction and acute complete obstruction of the large bowel are never treated conservatively but should be operated upon as early as possible. Conservative treatment of paralytic and mechanical ileus of the small bowel consists of constant suction applied to an indwelling intestinal catheter (Wangenstein or Miller-Abbott tubes), hot packs to the abdomen, fluids, and sedatives. The purpose of the hot packs is merely to make the patient more comfortable. Paraoral fluids, chiefly intravenous saline, replace water and electrolytes lost by vomitus, the urine, transudation of fluid into the lumen of the distended bowel, etc. Sedatives are usually not needed if the suction is working well and if just a simple obstruction is present. Narcotics should never be used for fear of masking signs of peritoneal irritation such as occur in strangulating obstructions. At this clinic, sodium luminal is given hypodermically for relief of restlessness and discomfort incident to confinement in bed. Fine has suggested the inhalation of 95 per cent oxygen to relieve the gaseous distention in intestinal obstruction. This is a valuable adjunct but the best results are obtained when its use is combined with siphonage drainage of the bowel (Wangenstein, Boothby).

*Erroneous Ideas Regarding the Conservative Treatment of Acute Simple Ileus of the Small Bowel.* Conservative treatment does not imply that suction siphonage is all-

sufficient and that the general condition of the patient may be disregarded. If the patient with intestinal obstruction is to be treated conservatively, constant vigilance must be given his condition. Flat plates of the abdomen (scout films) must be made every twelve to twenty-four hours, and the clinical status of the patient checked at frequent intervals. In using siphonage drainage, it is important that (a) the tube be in or beyond the duodenum; (b) the suction be working; (c) the fluid intake and output be carefully computed; (d) the plasma proteins and blood chlorides be checked frequently. At this clinic patients who have been treated by indwelling duodenal catheter with constant or intermittent suction for more than a week, are given a blood transfusion even if the plasma proteins are within normal limits.

It is foolhardy to use siphonage drainage as a diagnostic test of intestinal obstruction; that is, siphonage drainage should not be used in cases of ileus with the idea that if the patient does not improve he probably does not have a simple ileus and should be operated upon. An attempt to diagnose correctly the type of ileus should always be made before instituting therapy. The practice of employing suction as a test procedure to indicate whether operation will be necessary leads only to deferment of appropriate treatment (Wangensteen).

*Operative Treatment of Small Bowel Obstruction.* If one suspects a strangulation obstruction or in cases of simple ileus if suction is unsuccessful in effecting decompression, an operation is in order. At operation if the patient is markedly distended, and if a strangulating obstruction is not present, only an enterostomy should be performed. The importance of an aseptic technique in the performance of enterostomy has been stressed by Wangenstein. Spillage during the performance of an enterostomy in acute intestinal obstruction invariably means death from peritonitis. If a strangulating obstruction is found, freeing of the obstructing mechanism,

resection, or exteriorization of the affected bowel should be performed.

*Criteria for the Relief of Intestinal Obstruction and After-Care.* The criteria for the relief of intestinal obstruction in the conservatively, as well as in the surgically treated cases are the clinical and physical improvement of the patient and the absence of gas in the small bowel of adults by x-ray.

After removal of the siphonage tube the patient should be given a bland or low residue diet with mineral oil. Four to six weeks later a gastrointestinal study with barium sulfate by mouth (stasis ray) is performed to rule out any intrinsic obstructing lesion. The insertion of a Miller-Abbott tube down to the suspected site of the obstruction followed by the administration of barium through the tube will often aid in diagnosing an intrinsic obstructing mechanism. Occasionally a pneumoperitoneum is carried out to note the degree and position of intraperitoneal adhesions. In certain cases of intestinal obstruction secondary to pelvic inflammatory disease, Elliott treatment to the pelvic organs or other form of fever therapy is given, with or without a subsequent enterolysis.

Patients who present themselves with the abdomen scarred from many previous operations and have symptoms of acute mechanical intestinal obstruction, may be suffering from anorexia nervosa, or chronic morphinism. In our experience these patients are best treated by siphonage drainage. Enterolysis gives very unsatisfactory results in these cases.

*Theoretical Objections to Conservative Treatment of Intestinal Obstruction.* There are several theoretical objections that have been voiced against the conservative treatment of mechanical ileus:

1. In conservatively treated cases of mechanical ileus, one can only rationalize as to the obstructing mechanism, while if one operates upon all these cases, one can actually determine the nature of the obstructing lesion. Granting that this be

true, knowledge of the exact nature of the obstructing lesion is of little therapeutic value if the patient is markedly distended. In such cases it is more important to relieve the distention than to remove the blocking mechanism. Experience has shown clearly that obstructed patients with marked distention stand very little surgical interference. The statistics of Cheever and Körte show that the mortality of resection, enteroanastomosis, freeing of bands, etc., is three times greater if the bowel is distended than in the same operation done when the bowel is collapsed.

If the patient is very distended, it may be with difficulty that one finds the obstructing mechanism. Moreover, if the intestine is acutely dilated, exploration of the abdomen with the resultant trauma of the serosal coat of the bowel is dangerous. A serous peritoneal exudate is often changed to a purulent peritonitis by bacteria migrating through the bowel wall injured as a result of manipulation. Rather than explore cases of mechanical ileus with marked distention in which the site of obstruction is not evident, it is safer to perform a "blind enterostomy."

There is some danger that atypical cases of intussusception, obstructions due to impacted gallstones in the bowel, and strangulated internal hernia may be confused with simple obstruction and treated conservatively. In the case of intussusception, the age of the patient, the palpation of an abdominal mass, the presence of blood in the stool will be of diagnostic aid. One may not find rebound tenderness in cases of intussusception even though the intussusceptum be gangrenous if it is well ensheathed by the intussusciptens. Similarly in strangulated internal hernia, if the hernia be well ensheathed by the hernial sac, rebound tenderness may be absent. The association of ideal obstruction due to gallstones with a cholecystenteric fistula, resulting in gas being visualized in the biliary tree by roentgenograms, may be of value. The surgeon should always remember that if the patient with a supposedly

simple ileus does not improve with conservative therapy, some complication may be present and he should not temporize too long with the conservative régime. At this clinic by following this rule, we have yet to fail to recognize and institute proper therapy in cases of intussusception and intestinal obstruction due to gallstones.

2. Can one drain the bowel better by enterostomy or siphonage drainage? Theoretically suction applied through a tube inserted through the nose and passed into the duodenum accomplishes the same purpose as a catheter inserted into the bowel by enterostomy. Moreover siphonage drainage carries no operative risk. True, the most effective drainage is that obtained just above the obstruction; duodenal suction may be considered a non-operative form of "blind enterostomy." One is impressed by the fact that the amount of gas and fluid that escapes through an enterostomy tube is never so great as that obtained by suction from an inlying duodenal catheter in cases of ileus. However, the quantity and continuance of escape of gas and fluid in cases of intestinal obstruction are correlated more with the degree of obstruction rather than with the site at which the enterostomy is made.

3. If a patient with intestinal obstruction due to adhesions is treated conservatively and recovers, the obstructing mechanism is still present and may later be a potential source of danger. One must remember, however, that the patient probably had the adhesions for a long time before the ileus, but what caused them suddenly to become an obstructing mechanism is unknown. Since adhesive formation is part of the normal process of repair, if one operates upon such a patient, one has no assurance that the patient may not become obstructed subsequently by newly formed adhesions. Most surgeons would agree that a single obstructing adhesive band should be cut or removed. Just when to do this has been the subject of controversy. Our experience has been that if the patient is markedly distended, division

of the obstructing band is best deferred to a subsequent operation after the distention is relieved.

4. It is difficult to get a suction catheter into the duodenum? It takes but little practice to become proficient in passing a suction catheter through the nose into the duodenum. If the patient will not coöperate, if the obstruction has been of long duration, or if the distention is so marked that the duodenum or stomach is compressed or displaced, it may be difficult or impossible to get the tube into the duodenum. A special catheter with a leaded tip (Wangensteen tube) or the Miller-Abbott tube is used. To be certain of the location of the tube, an x-ray film of the abdomen must be made. Aspiration of bile does not prove that the tube is in the duodenum as aspiration through a tube coiled up in the stomach may reveal bile that has been regurgitated from the duodenum into the stomach. In an uncomplicated case, according to our technique, it takes about forty-five minutes from the time the Wangenstein tube is inserted through the nostril until its position in the duodenum is verified by x-ray.

5. Is siphonage drainage to be considered a substitute for surgery in intestinal obstruction? As mentioned before, strangulating obstruction and acute complete obstructions of the large bowel are never to be treated conservatively but should be operated upon as quickly as the condition of the patient permits. Siphonage drainage may be used only as an ancillary measure in these cases.

However in cases of simple ileus, as paralytic ileus and mechanical obstructions on an adhesive basis, siphonage drainage is not only a substitute for surgery but is to be preferred from the point of view of surgical mortality and end results. Colp, in 1936, in a review of the use of enterostomy at Mt. Sinai Hospital, New York City, conclusively proved that it had no place whatever in paralytic ileus. Van Beuren and Smith in a review of the literature found that the mortality of operation in

cases of acute ileus was about twice as great when an enterostomy was performed as when it was not. In 1937, these same authors reviewed the average mortality over a twenty-year period in cases of acute ileus operated upon at the Presbyterian Hospital, New York City. The mortality had been reduced from 66.6 per cent (1916 to 1919 inclusive) to 28.4 per cent (1932 to 1935 inclusive). They believed the reduction in mortality to be due to (1) earlier diagnosis and operation; (2) a clearer concept of the problem to be solved by treatment; and (3) more intelligent handling and management of the cases. This improvement applied to the cases upon which an enterostomy was effected as well as to those upon which it was not done but the reduction in mortality was much greater in the latter group. This discrepancy appeared to be due in part to the fact that the group in which an enterostomy was not performed was operated upon earlier.

In 1929, Miller published a study of 171 cases of intestinal obstruction from the New Orleans Charity Hospital covering the period 1923 through 1927. The mortality was 70.7 per cent. In 1934 Moss and McFetridge published from the same institution a series of 340 cases covering the period from 1930 to 1934. The mortality was 31.7 per cent, less than half of the series reported by Miller. In 1937, Boyce and McFetridge continued these studies, adding 204 cases covering the period from 1933 through 1935. The mortality was 36.3 per cent. This increase in mortality over Moss and McFetridge's series they believe to be due to the use of conservative therapy on ill-advised indications and in improper cases of intestinal obstruction.

Johnson, Penberthy, Noer and Kenning, in a series of fifty-four patients treated by intubation of the small intestine, reported a mortality of 25.6 per cent (fourteen patients). Of these, five, or 9.3 per cent, died as a result of intestinal obstruction. In the remaining nine who died, intestinal intubation was carried out to relieve disten-

tion associated with other conditions which caused death.

The experience of this clinic with all types of mechanical obstruction of the small bowel over a seven-year period between June 1, 1931 and June 1, 1938 has been reviewed by Wangenstein, Rea, Smith, and Schwyzer. Among 156 patients treated for acute mechanical obstruction of the small intestine, there were, because of repetition of obstruction in some patients, 190 cases. There were twenty-eight deaths in the entire group, a patient mortality of 17.9 per cent and a case mortality of 14.7 per cent.

Of the cases in which suction was the primary treatment although in some of these an operation became necessary to affect a satisfactory decompression, there were ninety-six patients and 126 cases of obstruction. There were fifteen deaths, a patient mortality of 15.6 per cent and a case mortality of 11.9 per cent. In those instances in which suction *alone* accomplished a satisfactory decompression and relief of the acute obstruction there were sixty-four patients and eighty-three cases. Five deaths occurred, giving a patient mortality of 7.8 per cent and a case mortality of 6 per cent.

At this clinic 61.5 per cent of patients and 66.3 per cent of cases of all patients with acute mechanical obstruction of the small bowel were treated by siphonage drainage. Suction alone was used for relief of the acute obstruction in 41 per cent of patients and 43.6 per cent of cases.

Of the patients with acute ileal obstruction treated by immediate operation, there were fifteen intussusceptions. The mortality of operation (usually reduction) in these cases was 40 per cent. The poor condition of most of these patients on admission to the hospital undoubtedly affected this mortality. Reduction by barium enema was attempted in ten cases; in eight of these the intussusception was partially reduced. In one of these the reduction was found to be complete at operation.

The mortality at this clinic in cases of strangulated inguinal, femoral, and incisional hernia (twenty-eight patients and twenty-nine cases) is 32.1 per cent of patients and 31 per cent of cases. However, in cases of strangulated incisional hernia, the mortality is 58.3 per cent (seven of twelve cases). It is our policy to operate upon these cases at once, no matter how grave the situation may appear. For strangulated incisional hernia division of the constricting bands without repair of the hernia would appear to be the procedure of choice. The prophylactic repair of all unobstructed incisional hernias is probably the best way to lower this mortality. From the work of Wangenstein and Scott the factor of blood loss into the gut is important in the lethal outcome of strangulation obstruction. At this clinic blood transfusions are given to all patients with strangulating obstruction even though there be no signs of shock. The importance of this procedure can not be overemphasized.

#### SUMMARY

1. The problem of acute intestinal obstruction of the small bowel resolves itself into a differentiation between (a) simple and strangulating types of obstruction and (b) acute obstructions of the large and small bowel.

2. In any case of ileus an integration of the history, physical findings, laboratory data, especially x-ray films, must be made.

3. Suction applied to an indwelling duodenal tube has a definite rôle in the treatment of acute intestinal obstruction. In acute mechanical and paralytic ileus complete relief of the obstruction may be obtained through this agent *alone*. In fact the lowest mortality yet reported for mechanical obstruction (6 per cent) has been with conservative therapy. Strangulating obstructions and acute complete obstructions of the colon should be treated by immediate operation. Siphonage drainage may be used as part of the treatment in these latter types of obstruction but its importance is secondary to operative treat-

ment of the obstructed gut. If the indications and limitations of suction in the management of obstruction are kept in mind, there can be no doubt that a definite lowering of the mortality of acute intestinal obstruction is obtained by this method.

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# OBSTRUCTION OF THE LARGE BOWEL

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**O**BSTRUCTION of the large bowel, because of its insidious onset and subtle progress, is a vicious and dangerous clinical entity. It becomes manifest in one of three forms, depending upon the degree of encroachment upon the lumen of the bowel, and the element of time involved in the progressive obliteration of visceral continuity. Clinically, this combination of circumstances evolves itself into either the acute, subacute, or chronic form of obstruction and if the time factor is prolonged, the individual case may progress through a series of all three of these stages in reverse order. The predominant cause of physiologic derangement in simple obstruction of the colon is distention, with subsequent damage to the bowel wall following progressive vascular occlusion from excessive intracolonic pressure.

Obstruction of the colon may or may not be associated with other pathologic changes in or about the bowel wall which profoundly alter the clinical picture, its course, treatment, and progress. These complicating factors therefore suggest the grouping of large bowel obstruction into: first, the simple mechanical obstruction as seen for example in bands, kinks and some of the congenital anomalies; second, obstruction superimposed upon malignant disease of the colon, diverticulitis, venereal strictures, etc.; and finally, the group in which obstruction is associated with a strangulating process such as volvulus, intussusception, or incarceration.

In the first group, simple mechanical obstruction is unassociated with other complicating processes which influence the general physical condition of the patient as well as the surgical approach. The second group includes those patients ravaged by coincident disease and suffering at times

profound physiologic depletion, which in itself is a serious problem to be dealt with in addition to the condition at hand. In the group which includes strangulation with obstruction, the picture is one of acute surgical shock and here again the entire course of the disease, its progress, and treatment are widely at variance with that of the first two types of occlusion.

The clinical picture resulting from large bowel obstruction differs greatly from that seen in obstruction of the small intestine because it is in effect a closed loop system. In addition to the inability to evacuate by regurgitation, the secretions of the upper alimentary tract are continuously being poured into the colon to supplement the existing accumulation of fluid and gas. This portion of fluid, arising from glandular secretions, according to Rowntree, reaches a total of approximately 7000 c.c. during twenty-four hours. About 1500 c.c. of saliva are swallowed daily, the stomach produces between 2000 and 3000 c.c. of gastric juice, while the biliary system elaborates some 500 to 800 c.c. of bile. Pancreatic secretions total between 300 and 500 c.c., while the succus entericus amounts to about 3000 c.c. In experimental obstruction of the colon in dogs, Wangenstein found that the accumulation of gas in the large bowel rather consistently about doubled that of the fluid content, and analysis revealed the following component gases in approximately these proportions: carbon dioxide, 6.5 per cent; oxygen, 1.2 per cent; nitrogen, 80 per cent; methane, 2.6 per cent; hydrogen sulfide, 6.7 per cent; and traces of hydrogen. In an analysis of the gases from a human colon obstructed by cancer of the rectum, the proportions very nearly approach these findings. There are three sources of gaseous



accumulation in the obstructed gut: the formation of gas from digestive processes; the diffusion of blood gases into the lumen of the bowel; and the atmospheric air swallowed. The latter, however, plays a small part in large bowel distention in contrast to obstructed small intestine.

A substantial portion of this rather surprising quantity of materials passes the ileocecal orifice through which it cannot be regurgitated because of the check valve action of the sphincteric mechanism. Although roentgenologists frequently report the passage of barium into the lower ileum, it must be remembered that the excessive weight of the barium, the rapidity and increased pressure with which it is introduced, along with the touch of the lead-gloved hand produce far from what may be considered optimum physiologic conditions. They overcome the force of the delicate muscle fibers of the ileocecal sphincter, while the slowly progressive effect of gradually increasing distention incident to obstruction serves to render it more impervious to back flow.

In the closed loop system of large bowel obstruction there is therefore an entirely different effect from that in obstruction of the small intestine. Vomiting is not a common occurrence early in the disease and is evidence of a long standing process. In consequence, electrolytic depletion and excessive dehydration with resulting alterations in blood chemistry are not factors of emergency importance. This is best evidenced by the relative uselessness of parenteral salt solution as contrasted with the dramatic results from its use in high intestinal obstruction. Likewise, the use of continuous duodenal suction is of small value in relieving existing colonic distention, although it may help to minimize the additional burden of a continuous flow of gas and secretions from the upper alimentary tract.

In obstruction of the large bowel unassociated with strangulation the principal causes of death are all dependent upon and directly traceable to the one outstanding

characteristic of the closed loop system—distention. The old theories of toxemia from the mysterious, highly-popularized, histamine-like substances have largely fallen into the discard. Distention is the "bête noire" of colonic obstruction and by means of this phenomenon alone the culminating tragedy of its subtle progress is inevitable.

With increasing intracolonic pressure the gut wall is stretched until paper thin, the muscle fibers lose tone to become exhausted, there is peristaltic inertia and ileus, with stagnation. The blood supply is soon comprised with first, venous occlusion, resulting in chronic passive congestion which, as the arterial flow continues, produces a condition analogous to strangulation with its shocking effect from excessive blood loss. The bowel wall then becomes edematous, small hemorrhagic areas appear, necrosis ensues, and perforation may result.

Tension on the bowel wall is directly proportional to the diameter of the lumen of the gut, and as Wangenstein has demonstrated, the tension per square centimeter in the cecum is over twice that of the descending colon. As previously mentioned, the effect of strangulating obstruction of the large bowel is primarily that of extensive blood loss into the injured segment, while massive tissue destruction with bacterial invasion due to abnormal permeability of non-viable gut, distention and ultimate perforation follow in rapid sequence. It is of interest to note that in spite of positive cultures from intraperitoneal lymph glands for a variety of different organisms, as reported by many observers, successful recovery following adequate surgical intervention is the rule.

Considerable work has been done to observe the alteration of bowel absorption in the obstructed gut. Absorption takes place through the portal system, the lymphatic system, and by means of permeability through the transperitoneal route. In the distended bowel there is a retardation of venous absorption but apparently

there is no definite proof of the absorption of toxic substances thought to be elaborated in the injured viscus. The lymphatic absorption of dye materials and bacteria is increased with a progressive rise of enteric pressure while permeability is proportional to tissue damage of the bowel incident to circulatory interference.

With enormous distention incident to obstruction of the lower colon or rectum, there is progressive cardiorespiratory embarrassment which adds to the individual's distress, but even more harmful and considerably less noticeable is the effect of venous congestion of the lower extremities. This phenomenon causes a relative decrease in blood volume with an excessive accumulation of metabolites, so that it adds to the shocking effect of simple obstruction in a manner somewhat similar to that of strangulation, although, of course, it is far more subtle and much less severe. There is likewise a decrease in plasma protein and blood volume incident to the accumulation of intracolonic fluid as well as intraperitoneal exudate which results from injury to the distended bowel wall. In animal experimentation with intestinal obstruction, the average loss of plasma volume has been found to be 36.4 per cent in four to six hours, or 2.8 per cent of body weight, 3.4 per cent of body weight being considered a lethal plasma loss. The mechanism by which distention causes plasma loss seems best explained by venous obstruction with a continuous arterial inflow resulting in gut wall edema and the intraperitoneal and intracolonic accumulation of the transudate.

Considerable work has been done on the determination of blood potassium in shock from hemorrhage and from trauma, in intestinal fistula and obstruction, and it has been found that there is a correlation between the prelethal state of these conditions and the blood potassium. Just what the similarity is which produces this physiologic alteration, is not altogether clear. Whether cause or effect, it remains to be determined, but there is definite

evidence of clinical importance in the work which is being carried on by Whipple, Scudder, Zwemer, and others.

### ETIOLOGY

The causes of colonic obstruction are many and varied and in order best to illustrate the types of disease which produce the condition, Table 1 is presented as a simple, practical, and approximately complete classification.

TABLE 1  
OBSTRUCTION OF THE COLON

Mechanical Obstruction	Congenital Obstruction
1. Adhesive bands	1. Imperforate anus
2. Volvulus	2. Atresia of the rectum
3. Intussusception	3. Anomalous termination of the colon
4. Hernia	4. Bands and constrictions
5. Foreign bodies	5. Megacolon
Neurologic Obstruction	Extrinsic Lesions Causing Obstruction
1. Adynamic ileus	1. Adjacent malignant disease
2. Spastic ileus	2. Pelvic tumors
3. Hirschsprung's disease	3. Mesenteric cysts and tumors
4. Chronic obstipation	4. Adjacent inflammatory disease
	5. Retroperitoneal tumors
Inflammatory Disease	Intrinsic Lesions Causing Obstruction
1. Diverticulitis	Post-ulcerative Strictures
2. Appendicitis	1. Tuberculosis
3. Epiploitis	2. Actinomycosis
4. Lymphogranuloma venerea	3. Ulcerative colitis
5. Syphilitic strictures	4. Amebic or bacillary dysentery
6. Gonorrheal strictures	5. Chemical ulceration
7. Nonspecific	6. X-ray and radium
Post-traumatic	Malignant Disease
1. Direct trauma	1. Adenocarcinoma
2. Detachment of mesentery	2. Epidermal carcinoma
3. Small mesenteric thrombosis	3. Sarcoma
4. Post-incarcerational stricture	
5. Injury from over-distention	

*Mechanical Obstruction.* Mechanical obstruction of the colon in the simplest form is rare and is usually caused by post-operative or congenital bands which gradually contract upon the entrapped bowel first to retard and finally to occlude the passage of intestinal content. Angulation

from postoperative adhesions may produce a similar sequence of events while foreign bodies must also be included in this group. Extracolonic pressure alone from retroperitoneal or intramesenteric cysts or tumors have all been reported as causative agents, as have pelvic tumors, although the latter are rare, for the colon may, through its mobility and pliability, so readily adjust itself to such conditions that it rarely becomes pinned between fixed structures. Recently we operated upon a patient with a large lipoma of the mesentery of the sigmoid which had begun to encroach on the lumen of the gut.

Herniae of all varieties have been noted as causes of obstruction by incarceration or strangulation. Inguinal, femoral, umbilical and incisional herniae have all taken their toll. Diaphragmatic herniae, internal herniae of various sorts and congenital openings of the mesentery have likewise been observed.

*Congenital Obstruction.* Congenital obstructive abnormalities of the colon are not exceedingly rare and when present are frequently associated with anomalies elsewhere. They range all the way from the imperforate anus to entire atresia of the colon. The continuity of the large bowel may culminate in a small fistulous tract which opens into the bladder, the urethra, the vagina, or the vulvovaginal orifice. The anus or rectum may be entirely absent, or with the fully developed anus and failure of descent of the rectum, a simple membranous diaphragm may be present, whereas the two blind pouches may be joined by a fibrous cord. Narrowing of the anal canal may occur, which produces a partial obstruction. This may be present in the form of a stricture-like process, or involve a segment of the bowel. It is at first in no sense of the word a stricture, but with subsequent trauma it may through constant irritation develop into a true cicatricial process. The etiology of Hirschsprung's disease is far from clear, as evidenced by the total of a huge list of theories advanced by many authors, but

it is generally believed that certain types of megacolon are definitely related to developmental abnormalities whether they be obstructive, neurogenic, or structural defects such as redundancy of the rectosigmoid or elongation of its mesentery.

*Volvulus.* Volvulus of the colon is a result of torsion on a long mesentery and most commonly occurs in the sigmoid, although the cecum, both flexures, or the redundant transverse colon may become involved. When the process reaches 180 degrees rotation, obstruction is supplemented with the effect of strangulation for beyond this point vascular injury is inevitable. Volvulus may occur in one of three ways: first, by circular rotation about a fixed point; second, by an elliptical rotation about two fixed points; and third, by rotation about the longitudinal axis of the viscus. Presupposing the necessary anatomic factors, the catastrophe may be precipitated by various exciting causes such as violent peristalsis following heavy purgation, overeating, tumors, mesenteric cysts, fecaliths, foreign bodies or direct violence. Pregnancy has been mentioned as a causative agent, but it is probably a coincidental finding in most cases.

*Intussusception.* Intussusception is an interesting form of obstruction of the colon which most commonly occurs in infancy and childhood and is often associated with vascular damage dependent upon the extent and duration of the process. Multiple intussusceptions are said to occur in 10 per cent of the cases, although Clubbe in a series of 253 cases reported it to be present in 31.8 per cent, while Crohn noted it eleven times in fifteen cases. Intussusception may be of four types: first, involving only the small intestine; second, involving the small intestine which has prolapsed through the ileocecal valve; third, intussusception of the ileocecal valve itself into the colon; and finally, when only the colon is involved in the process.

A combination of circumstances, producing hypermotility plus the anatomic considerations observed in infancy and

early childhood are believed essential to the majority of such cases. The frequency with which ileocecal and cecal involvement occurs, lends credence to the hypothesis of Perrin and Lindsey who feel that hypertrophic lymphoid structures about the ileocecal valve and terminal ileum act somewhat as do polyps or foreign bodies which in the face of abnormal peristalsis tend to become prolapsed into the distal gut.

*Functional Obstructive Disorders of the Colon.* In discussing this group of conditions which lead to varying degrees of colonic obstruction, the multiplicity of theories as to the etiology of chronic obstipation, intestinal stasis, megacolon, and the like, presented in the vast literature on the subject are productive of a discouraging paucity of fact. Suffice it to say that bad habits, inertia, chronic nervous exhaustion, as well as hypo- or hyperneurogenic activity, vitamin deficiencies, and similar vagaries seem to play an important rôle in some of the more exaggerated forms of chronic obstipation. However, it has been repeatedly observed that in the aged, the sick, the indolent, decrepit, and insane, fecal impaction is a prevalent cause of obstruction. Hirschsprung's disease though discussed under congenital disorders of the colon, must in some instances fall into this group of disorders.

*Inhibitory Ileus.* Inhibitory ileus, often spoken of as adynamic obstruction, can be as difficult and dangerous as any form of intestinal obstruction. The motor balance between the sympathetics and parasympathetics has been disturbed by an excessive sympathetic stimulation which completely inhibits all motor activity. It may develop from intra- or extra-abdominal trauma, surgical or otherwise, infections such as peritonitis, pneumonia, and other septic conditions, while extra-abdominal conditions such as fractured ribs, renal calculus, torsion of the testicle, etc., may be responsible. Usually the entire intestine is involved. Occasionally, however, only portions of the small or large bowel may be affected.

*Spastic Ileus.* Spastic ileus is usually segmental. The gut is intensely contracted and obstruction is complete. Hyperirritability may result from injury, foreign bodies, worms, or irritating intestinal content, etc. The spastic segment may be in the form of a ring-like constriction or involve a large segment of gut. It may occur in the colon or small intestine and for a time persist in causing an obstruction which is difficult to differentiate from simple mechanical obstruction.

*Inflammatory Processes.* Heading the list of inflammatory processes which cause obstruction of the colon, is diverticulitis. Acute appendicitis, and acute epiploitis have also been recorded, while the group of processes which fall into the classification of granulomatous diseases of the large bowel contribute an appreciable percentage of obstructing lesions. Commonest of these is lymphopathia venerea. Tuberculosis (hyperplastic in the cecum), and actinomycosis rarely produce obstructing lesions of the colon, while syphilis and gonorrhea are considered as equally rare causes of anorectal strictures. Lymphogranuloma venerea has in the past decade been given considerable study, and it is probably the true cause of the many lesions which in the older literature were classified as non-specific, gonorrheal, or syphilitic.

Ulcerative processes in the mucosa of the large bowel caused by ulcerative colitis, dysentery, chemical ulceration, or contusions may produce cicatricial stenosis of the colon, while a localized injury to the blood supply such as a small infarction, thrombosis, or tearing of the mesentery, may produce a similar lesion. X-ray or radium used in the treatment of cervical, fundus, or bladder cancer have caused extensive inflammatory strictures of the rectum or rectosigmoid. We have operated upon two such cases in the past six months.

The commonest among the obstructing lesions of the colon is cancer. In discussing malignant disease of the large bowel, it should be remarked that rarely has sarcoma of the colon arising from the submucosal

structures been recorded as encroaching upon the visceral lumen. Epidermoidal carcinoma usually appears at the mucocutaneous juncture of the anus, but occasionally is found to arise from the mucosa elsewhere in the colon. Endometriosis, although not considered a malignant disease, may likewise invade the colon. The authors have observed and treated two such cases during the past year.

Due to the frequency with which carcinoma of the colon causes obstruction, either partial or complete, the surgical significance of this type of lesion is self-evident. The growth is nearly always in the left colon, rectum, or left half of the transverse colon, although it may occur well up toward the hepatic flexure. Occasionally a carcinoma of the cecum will, by dint of its unusual size and proximity to the ileocecal valve, produce obstruction of the terminal ileum. This, however, is rare and under such circumstances the picture is one of small bowel obstruction.

Cancer of the colon may appear in the form of an ulcerative, penetrating lesion characterized by a paucity of glandular tissue which is thinly scattered throughout a fibrous superstructure, giving the effect of scirrhus carcinoma. Grossly, there is a raised, irregular, granular ring encircling the ulcer which has a flat necrotic center. As the ulcers gradually increase in size, more and more of the bowel wall becomes involved and cicatrization gradually causes a stricture-like closure of the lumen. Again, a small nodular mass with minimal ulceration may cause an occluding stricture or a large annular growth may completely encircle the lumen of the bowel. Still other carcinomata may be the polypoid protruding types, which project well into the lumen of the bowel. Microscopically, these tumors are composed mostly of the glandular element with minimal fibrous tissue framework. All variations between these two extremes may be found, as well as the gelatinous carcinoma which is a highly differentiated glandular tumor, the acinous cells of which are mucus-secreting. Ob-

struction is less often observed in the latter because the protruding types of growth usually cause them to be discovered before obstruction has developed. Due to the larger diameter of the right colon and the fluid character of its content, obstruction rarely occurs in the right half of the bowel, but it is far more common with lesions beyond the mid-portion of the colon than is generally suspected. Burgess, in a study of 485 cases of cancer of the colon, observed the incidence of obstruction to be 35 per cent. Statistics in this country from large urban hospitals are higher.

As the process progresses the lumen may be decreased to a centimeter or less in diameter before complete obstruction occurs, but during this time the bowel wall proximal to the growth has become thickened and hypertrophied, and the mucosa engorged and edematous with areas of ulceration caused by the impaction of inspissated fecal matter. The final step in the occlusion is usually the inflammatory reaction and edema incident to irritation and infection, although it may be caused by the accumulation of fecal matter above the lesion. Too often even now the catastrophe is precipitated by the oral administration of barium at the hand of the over-enthusiastic roentgenologist. This has repeatedly resulted in death and cannot be too emphatically condemned.

#### SIGNS AND SYMPTOMS

Colonic obstruction is usually a slowly progressive process ushered in by episodes of mild colicky pains and abdominal distention. There may be alternating periods of diarrhea and constipation or the latter may progress to obstipation in spite of repeated medication. On the other hand, the first evidence of colonic disease may be complete occlusion of the bowel. This type of onset is most commonly observed in elderly patients found in the large charity clinics and city hospitals. Not infrequently these patients can point to the exact site of obstruction, which is usually a result of carcinoma. When not associated

with incarceration or strangulation, even complete obstruction of the large bowel may be a subtle and insidious process. Slowly progressive abdominal discomfort gradually develops into intermittent cramping pains which increase in frequency and severity as distention becomes more and more pronounced. This distention never produces prominence of the lower mid-abdomen with stepladder pattern and visible peristalsis as seen in obstruction of the small intestine. Protruding of the flanks and upper abdomen are typically present in obstruction caused by lesions low in the colon and as meteorism increases and abdominal discomfort progresses, patients complain of indigestion, lassitude and weakness. They become restless, apprehensive and drawn in appearance. The skin is dry, the pulse quickens, and while the picture is one of impending disaster, these patients rarely vomit, although they may at times complain of nausea.

The symptomatology of obstruction from cancer of the colon is dependent upon two factors: the difference in physiologic function of the right and left half of the large bowel and the pathologic variation observed in carcinoma in the different segments of the colon. Because of the great diameter of the cecum and ascending colon, the fluidity of its content, and the noncatrizing proliferative type of growth, it may be easily understood why obstruction is not a predominant feature in cancer of the right colon. Lesions in this half of the bowel are either discovered accidentally as a palpable mass in the right lower quadrant, or present one of two symptom complexes: the vague dyspeptic picture, or the severe anemia. The former are usually diagnosed as chronic appendicitis, chronic cholecystitis, or intestinal indigestion, while the latter are often confused with pernicious anemia. Carcinoma of the left colon is manifest by irritability of the colon with change in bowel habit, intermittent spells of diarrhea or constipation, blood in or on the stool, and all other manifestations of an obstructive process. Pain, cachexia,

and weight loss are late manifestations of malignant disease and suggest metastasis.

In striking contrast to this insidious course, the sequence of events following obstruction of the colon associated with incarceration, strangulation, or intussusception, moves with a terrifying rapidity often associated with agonizing pain and early prostration. Distention is quick to appear and often extreme in its intensity. The pain is generalized, often variable in persistence and in severity, but always associated with tenderness as evidence of peritoneal irritation. A palpable mass may or may not be present but with intussusception, the classical tumor is usually found and the diagnosis is relatively certain.

#### DIAGNOSIS

Frequently, the diagnosis of intestinal obstruction, acute or subacute, is made with little difficulty, but this is by no means a constant observation. Usually a history of episodes of cramping colicky pain, progressive abdominal distention, obstipation, nausea and vomiting are the predominant features which combine to portray the clinical picture of intestinal obstruction. Having concluded that there is an obstruction to the continuity of the gastrointestinal tract, the site of this lesion is a matter of great importance. The differentiation between large and small intestinal obstruction is evidenced clinically by the rapid progressive depletion incident to intractable vomiting, the step-ladder pattern, and visible peristalsis characteristic of small intestinal obstruction, in contrast to the slow development of meteorism with flank distention and milder, more generalized, colicky pain. Often one or more stools may pass following the onset of small gut obstruction, but this is rarely seen in colonic obstruction.

Localization of the process is of importance because of its bearing on treatment. Perhaps the most helpful procedure recently developed for the diagnosis and location of an intestinal obstruction is an

x-ray of the abdomen. Here the intestinal patterns are visualized and with skilful interpretation, the site and type of lesion may often be determined accurately. Naturally, the ingestion of barium is not a part of the procedure, but a flat plate only is taken.

#### TREATMENT

Therapeutic measures to be instituted in the face of colonic obstruction are dependent entirely on the nature and duration of the obstructing lesion. The variation in treatment may range from enemata through the simple nick of a congenital membrane occluding the imperforate anus, all the way to resection of a large segment of strangulated bowel caught in the twist of a volvulus.

Usually the congenital obstructions are best treated by early surgical intervention; for if the process is evident shortly after delivery the infant is then at its best and delay will only serve to deplete its reserve and increase the detrimental effects of the obstruction.

In colonic obstruction of adults, not infrequently, what appears to be a complete obstruction of the colon can be relieved by the adroit use of enemata, thereby eliminating the need for emergency surgical decompression. In obstructing carcinoma of the left colon and rectum, an appreciable percentage may be added to this group—if patience and care are used in giving repeated irrigations with large quantities of fluid.

Physiologic changes incident to the presence of chronic depleting disease, or acute septic processes must be combated by means of parenteral fluids, blood transfusions and vitamin concentrates. The recent advances in chemotherapy have been beneficial in the management of septic complications occurring in diverticulitis and there is slight evidence to suggest the value of sulfanilamide in the treatment of lymphopathia venerea.

During the preoperative preparation of completely obstructed patients suffering

from progressive distention, the use of 100 per cent oxygen has, in our hands, been found quite effective. The procedure is simple, requiring only the mask pressure gauge and oxygen tank and in the course of four or five hours, while other supportive measures are being carried out, distention is appreciably reduced, the comfort and general condition of the patient are improved and the surgical endeavor is greatly facilitated.

In the strangulating obstructive processes, the element of primary importance to be combated is the shock incident to decrease in blood volume. Blood loss into strangulated tissues is no more nor less than active hemorrhage and must therefore be treated as promptly and vigorously as intra-abdominal bleeding from a ruptured viscus. It must be emphasized here that in strangulating injuries of the bowel, if the vascular occlusion can be relieved before mesenteric thrombosis has occurred, deflation of the affected segment by means of a fine needle and hot salt packs to the bowel for as long as five minutes by the clock, will often revive what appeared to be a hopelessly devitalized segment of gut. Careful inspection and palpation of the mesentery is, however, essential before one is justified in abandoning resection. One or two adroitly placed sutures should prevent the recurrence of a volvulus or intussusception if one is so fortunate as to discover he has explored in time to find viable gut.

If, on the other hand, a large segment of bowel has become gangrenous, the procedure of choice is an obstructive resection and complementary cecostomy. Rarely can a primary anastomosis be performed, but even here, the complementary cecostomy, a matter of only several minutes, will greatly improve the prognosis. Primary anastomosis is to be condemned for the following reasons: (1) because it is a time-consuming operation and it is difficult to be sure of safe blood supply to the bowel ends; (2) end-to-end anastomosis is, moreover, not only dangerous, but impractical

because of the difference in the diameter of the lumen of the gut above and below the obstruction; (3) the suturing of edematous gut in the side-to-side anastomosis is unsurgical and requires excessive time; and (4) the majority of strangulating obstructive lesions of the colon occur on the left side where the fecal content is no longer fluid, an additional factor to jeopardize the anastomosis which even in the properly prepared colon, heals none too kindly.

Exteriorization of a large loop of gangrenous gut, often pictured in the older textbooks and all too frequently done even now, should be assiduously decried. The procedure is often actually harmful. In the first place, it does not relieve obstruction; secondly, it is a continuous source of tissue fluid loss through osmosis and diffusion; thirdly, it is for the same reason a constant source of toxic absorption and bacterial invasion; and finally, if the arterial supply is not divided and ligated, small quantities of blood continue to flow through the lesser arteries and arterioles which pass into the viable extremities of the exteriorized loop, while the smaller veins at the borderline area, far more easily compromised than the arteries, fail to return it to the systemic circulation. Furthermore, if time can be taken to ligate the blood supply only a few more minutes are required to apply a clamp and convert the entire affair into a precise, surgical procedure which not only greatly facilitates adequate closure of the abdominal wound, but eliminates the imminent possibility of subsequent peritonitis, wound infection, or evisceration.

The rationale of therapeutic attack in obstruction of the colon is dependent upon procedures calculated to protect the viability of the bowel wall against overdistention and vascular damage; in short, decompression and relief of strangulation. The latter is always an emergency measure and usually the process demands immediate eradication. If, however, the obstructive agent does not jeopardize the blood supply, as in the case of neoplastic or

chronic inflammatory disease, decompression is the single aim of surgical invasion.

In the acutely ill patient, the obstructive process having been localized to the colon, the procedure of choice often is blind cecostomy through a split muscle incision in the right groin, performed under local anesthesia. When possible, it is advisable to exteriorize the cecum or a portion of the ascending colon in order completely to by-pass the fecal current and to permit of subsequent irrigation which cleanses and rehabilitates the bowel, preparatory to surgical extirpation of the obstructing lesion. Although the cecum may often be delivered with ease, this is not always the case. Great difficulty may be encountered when the cecum is firmly fixed to the parietes, and again when it is hugely distended and its wall paper-thin, the danger of perforation from the gentlest manipulation is imminent. Under such circumstances, it is best to pack carefully around a portion of the anterior wall of the cecum, and by means of a small needle, withdraw the gas. The relaxed wall rapidly becomes thickened by engorgement of the mucosa, and edema of the submucosal and serosal coat, so that it may be more easily handled with less danger of perforation and soiling. Having accomplished this, there remains the choice of suturing a tube, preferably a large one, into the bowel, suturing the bowel to the peritoneum, or fashioning a loop cecostomy.

Recently, in our service, cecostomy for the relief of acute intestinal obstruction has been performed sixteen times. In eight of the cases, subsequent resection was impossible, and in the remaining eight, obstructive resection completed the procedure. Table II shows the conditions which caused the obstruction.

TABLE II

CECOSTOMY FOR ACUTE INTESTINAL OBSTRUCTION	
Cancer of transverse colon.....	3
Cancer of sigmoid.....	5
Cancer of rectum.....	2
Cancer of rectosigmoid.....	1
Postoperative adhesions, large and small bowel	1
X-ray stricture of descending colon.....	1
Cancer of left colon.....	1
Cause unknown.....	2



The danger of abdominal exploration in the face of acute obstruction should be emphasized, for it does, without question, greatly increase the risk of complicating sequelae. Likewise, the danger of sudden collapse following rapid, complete decompression of the hugely distended colon is analogous to that following immediate relief of urinary obstruction and must be borne in mind. The mechanism of this catastrophe is not altogether clear, but it seems entirely probable that the sudden flow of blood into an atonic vascular bed produces a puddling or stagnation of blood and tissue fluids in the engorged wall, which creates in effect a decrease in blood volume analogous to hemorrhage. Care must therefore be taken to avoid precipitous evacuation of distending media.

Once the patient has recovered from the effects of decompression, local and general measures of rehabilitation are begun in order to prepare for subsequent surgical removal of the obstructing lesion. If, up to this point, a definite diagnosis has not been reached, the search may now be carried on without danger to the patient. Proctoscopic examination may be used to explore the rectum and recotsigmoid for lesions beyond the reach of the examining finger. If the

site of the obstruction has not been revealed by a flat plate of the abdomen as previously suggested, a barium enema is then indicated.

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# ACUTE PERFORATIONS OF "PEPTIC" ULCERS

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IN order that this discussion be confined within the limits of the space allocated to it, I will not discuss the intermittent perforations which progress by a series of acute attacks; each of which penetrates deeper and deeper into, or through, a resisting wall. Some of these communicate with localized and well walled off abscesses, and a few establish fistulae with some other portion of the intestinal tract, such as the justly dreaded gastro-entero-colic type. Nor will I discuss perforations usually found on the posterior wall and associated with massive hemorrhage, for these constitute a somewhat different problem.

As a general rule, it is easy to make the correct diagnosis of an acute perforation of a gastric or duodenal ulcer from the clinical picture, and to do so without the aid of the x-ray. In the vast majority of cases, the x-ray is of confirmatory assistance only, but, it should be used in every case where it is possible to do so. In only one case have I seen it to be of distinct harm, and, there the damage was due not to the x-rays, but to the delay engendered in convincing the radiologist that a patient could have an acute perforation of the gastrointestinal tract without the x-ray plate showing the air space between the liver and the diaphragm when the picture was made with the patient in the erect position. In this particular case the air bubble did not appear in the x-ray picture until about six hours after the clinical symptoms indicated perforation.

There is another misunderstanding attached to this gastrointestinal "blowout." Such is in the form of a dictum, namely, "bleeding ulcers don't perforate and perforating ulcers don't bleed." Such expressions, as a rule, are employed to offset some bad practice in vogue at the time they are

made, and there probably was a time when doctors considered bleeding a necessary forerunner of perforation. Certainly there is no need for such a dictum now, for I doubt very much if there is a single one of the readers of this article who has not seen bleeding ulcers perforate and perforating ulcers bleed.

In about one-half of our cases it was difficult to obtain before operation any definite history that would suggest the existence of the ulcer before its perforation. Quite a few of our patients have had their perforations following an over-indulgence in food and fluids, often alcoholic in type. Most of these patients have been men, and even after operations for the closure of an opening, it has been difficult, and in quite a few instances, impossible to obtain any history that would indicate the existence of the ulcer before the actual perforation.

In only two of our seventy-one cases of acute perforations of peptic ulcers has there been any history of association of trauma with the perforation. The trauma in one of these two was due to an automobile accident, and in the other resulted from the impact of a plow handle when the point of the plow hit a large rock. Both of these accidents occurred shortly after the patients had over-indulged themselves at their midday meal, and when they probably had distended stomachs. Certainly the finding of large quantities of food, etc., in the peritoneal cavity when first opening the abdomen at least suggested that such was the case, and both admitted they had eaten unusually "hearty." Both of these patients had been treated for their peptic ulcers for several years before the time of the above-mentioned accidents, and therefore knew of the existence of their ulcers

before the accidental trauma aided in the perforations.

It has been stated that the treatment of ulcers by histidine prevents perforations. However, two of our cases with acute perforations were under treatment with histidine when this emergency occurred, and this in spite of the fact that this form of treatment is not very general in our community.

It is interesting to note that in these seventy-one cases of acute perforations of peptic ulcers, only thirty-two had been treated for their ulcers. Of the remaining thirty-nine it was possible to obtain histories of the previous existence of the ulcer in twenty-seven, but their symptoms were not severe enough, in their opinions, to require treatment. In the last twelve, even after the operation, we were not able to obtain any history that would indicate the existence of the ulcer before perforation, unless three patients who had been previously treated for some sort of "coronary occlusion" are included. None of these three have had any return of their cardiac symptoms since operation.

It is, I think, generally conceded, even by the most radical adherents of the non-surgically inclined of medical men, that properly executed surgery offers the best hope of recovery. If this statement is correct, then that brings up the consideration of what constitutes "properly executed surgery." Certainly the prevention of any unnecessary delay in the time of starting the operation is almost as valuable as prevention of rapid manipulations done in a rough manner during the operation. These break up early protective adhesions and increase the soiling of the peritoneal cavity. Sufficient time should be taken before operation for the insertion of a duodenal tube with suction through the nares as well as the giving of the correct intravenous medication to establish and maintain proper fluid balance.

While some of my surgical friends have found comfort in the employment of spinal anesthesia by obtaining freedom from

abnormal respiratory movements being transmitted to the field of operation, it has been my observation that in the vast majority of cases the blood pressure in these patients after intestinal perforation is too low to justify such an anesthetic. Unless one is able to establish a mental equanimity concerning the margin of safety in the relationship of low blood pressure and spinal anesthesia, then the inhalation anesthetic to which the anesthetist is accustomed should be given. I feel I have some right to have a definite opinion in regard to this drug, for I have both experienced the comfort and lost the mental equanimity associated with spinal anesthesia.

The type of operation to be performed, of course, depends on the conditions found on opening the abdomen. Each case presents a separate individual problem, which requires the application of sound surgical judgment rather than dexterity. Extensive operative procedures should not be done in an infected field. If the history of the perforation is of sufficient duration to have allowed an extensive peritonitis to have developed, the less operating done in such a field the better for the patient. While the surgeon is isolating the perforation and applying whatever operative procedure he considers indicated, it should be the duty of an assistant to clean gently the peritoneal cavity, preferably by aspiration. It is important to aspirate the food and other gastric contents from the pelvic cavity and iliac fossae, to which such material so frequently gravitates.

Unless there is some very definite indication to the contrary, it is our practice simply to close the ulcer with No. 1 chromic catgut sutures. In a few cases, the infiltration surrounding the perforation has been so extensive, and the condition of the patient so precarious that we have sutured a small portion of the omentum over the opening. It is rather interesting, and perhaps instructive to notice how frequently in these cases the omentum is found in the neighborhood of the opening, as if it were attempting to plug or close the perforation

without "surgical aid"—somewhat in the way it behaves as regards an acute appendix.

There is apparently a tendency at the present time to institute operative procedures which will prevent the necessity of secondary operations. I am sure the sooner we surgeons realize that surgery can only be an aid, though often a most important one, in the treatment of "peptic" ulcers, the better such an attitude will be for the ultimate satisfactory condition of our patients.

The very natural and laudable desire on the part of the less experienced, but thoroughly conscientious surgeon, to prevent future operations will sometimes lead him to perform extensive procedures, into which a more experienced surgeon would not be tempted. Perhaps I have come to this conclusion by having had the opportunity on a few occasions to examine the pyloric openings some months after the closure of the perforation while doing operations for unrelated conditions. On these few occasions, I have been impressed by the small thin scar and the absence of adhesions around the site of the perforation. It is possible that the lack of adhesions might be due to the presence of digestive enzymes free in the peritoneal cavity at the time of perforation. In addition to these rather surprising sequelae, the pyloric opening has been found to be larger than normal, and the annular sphincter muscle less definite on palpation than is usually found when there has been no involvement by disease in this locality. Such findings naturally make one wonder if there might not have been an accidental division of the pyloric muscle by the actual perforation itself or by the infolding sutures cutting across this muscle during the weeks following the operation. However, in spite of these conjectural observations, about 6 per cent of our patients who have had only simple closures at the time of the primary operation, have required additional operations to relieve gastric retention or to aid in the medical care of the ulcer.

Some years ago we thought that a posterior gastroenterostomy at the time of the closure of the perforation gave relief from postoperative gastric distention. At the present time continuous suction through the small duodenal tube prevents gastric distention, and, therefore, this excuse for the addition of a gastroenterostomy no longer exists. We are now using this suction through the tube almost as a routine measure following all abdominal operations or other lengthy procedures. This practice has been of great comfort to our patients by almost entirely eliminating postoperative vomiting and "gas pains."

I am sure it is reasonable to presume that one of the reasons secondary operations are not more frequently necessary is to be found in the patient's willingness to cooperate in the subsequent medical treatment. The alarming surgical experience causes apparently confirmed cigarette smokers to shun tobacco as if it were poison, which it unquestionably is to many of them. A more general realization by both the laity and the profession of the causal relationship between cigarette smoking and "peptic" ulcer formation might prove to be a prophylaxis against this disease.

The solution of the question as to whether to employ drainage after these perforations is only another instance of selecting the proper procedure for the individual case. However, surgeons generally consider that drainage is not indicated in the vast majority of cases. It is a natural temptation to institute drainage, especially after finding a large quantity of food and gastric contents scattered around the peritoneal cavity, but one should recall the inhibitory effect of hydrochloric acid on the growth of bacteria and the fact that acidity is usually high in "peptic" ulcer cases.

Frequently drainage, if placed close to the site of closure of the perforation will be followed by the formation of a gastric or intestinal fistula with all its distressing results. The formation of such a fistula

leads to the gradual death of the patient often after some weeks of starvation of the body and painful digestion of the skin by the escape of gastric and duodenal juices. If the soiling of the peritoneal cavity has been great, and the resulting peritonitis extensive, we have made it a practice to close the peritoneum with interrupted catgut sutures, place silver wire splinting sutures through skin, fascia and muscle, and not tighten these sutures,

but pack the incision with some antiseptic gauze. After several days, depending on the patient's general condition, this gauze is removed, and the through-and-through wire sutures tightened over buttons after the manner described by Shipley.

If the peritonitis has been sufficient to allow the formation of localized abscesses, these are drained by cigarette drains, but gauze is never placed near the site of the closure of the perforation.



HIPPOCRATES knew and described surgical conditions varying from congenital club foot to fracture of the spine. We have never improved on his clinical pictures.

# TREATMENT OF ACUTE MASSIVE HEMORRHAGE IN PEPTIC ULCER

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ONE of the most important complications of peptic ulcer is gross hemorrhage. Manifested either by hematemesis, by melena, or by both, and often accompanied by the syndrome of shock and syncope, it constitutes a most alarming symptom and always causes the patient to seek medical care.

Because it is such an impressive symptom, fairly accurate statistics regarding the incidence of hemorrhage in gastric, duodenal, and anastomotic gastrojejunal ulcers can be obtained from the clinical histories of ulcer patients. The incidence in several large series indicates that about 20 per cent, or one in every five patients with peptic ulcer experiences one or more gross hemorrhages at some time during the course of his disease. Hemorrhage is relatively more frequent in gastric ulcers than in duodenal ulcers, and is even more frequent in the anastomotic or jejunal ulcers.

In spite of the alarming nature of the symptom, there has been a general impression held by the medical profession, that patients rarely died from gastric hemorrhage, and that the mortality from hemorrhage in peptic ulcer was negligible. This impression seems to have arisen from general experience, or more accurately, from generalized lack of experience with any large group of cases of gross bleeding from the gastrointestinal tract. In the last few years, reviews of the actual experience in hospital and clinic practice has shown that hemorrhage from gastric or duodenal ulcer incurs a distinct mortality, and that patients do occasionally bleed to death from a peptic ulcer. Blackford found in the vital statistics from the city of Seattle that in a two year period, there were 124 deaths from peptic ulcers, of which forty-two were

recorded as being due to massive hemorrhage. However, the actual mortality rate associated with this complication has recently been a matter of considerable dispute. One has only to peruse the literature on this subject to become astounded at the marked discrepancy in the mortality statistics reported by various authors. There is no possible doubt but that these disparities, between the wide limits of 1.31 per cent and 58 per cent, are due largely to the study of dissimilar groups and to lack of application of uniform criteria of diagnosis and results. One finds some authors reporting on groups which include cases of cancer, ruptured varices, and acute gastric erosion. Some authors include occult bleeding under the diagnosis of hemorrhage, while others consider hematemesis only in their study. Many papers fail to state the relative incidence of mild and severe hemorrhages, or even reveal what criteria were used in judging the severity of cases. Differences in the clinical material from which the cases are drawn obviously introduces another variable factor in the calculation of mortality. A large metropolitan hospital furnishing an emergency and accident service, and serving a poorer class of population, might well be expected to receive a higher proportion of severe hemorrhaging cases than would be found in the experience of a private clinic. After a review of the literature, one must conclude that there are relatively few papers which offer any distinct aid in estimating the prognosis in gross hemorrhage from peptic ulcer.

Crohn and Lerner report a mortality of 6.5 per cent in a series of 215 patients treated medically and a total mortality of 11.6 per cent when they included seventy-

five patients who were operated on. This figure is probably considerably higher than the actual mortality rate of all cases of gross hemorrhage. The Mount Sinai group of cases which was studied by Crohn and Lerner undoubtedly contained a disproportionately high percentage of severe cases and severe hemorrhages, possibly occurring in a larger percentage of patients who are in generally poor condition.

Hurst and Ryle have pointed out that the only true mortality can be ascertained from statistics gathered by general practitioners, since they have the opportunity of seeing all cases of hemorrhage, either mild or severe, before they are segregated into hospitalized and non-hospitalized cases, medical and surgical cases.

The combined experience of twenty-seven practitioners in and around London was a total of 677 cases of hematemesis and melena with nine deaths, which was a mortality of 1.31 per cent. Since the method of collection of these figures is unknown and probably incomplete, a mortality of 1.31 per cent is probably lower than the actual figure. It would seem, therefore, that the general mortality rate for gross hemorrhage lies somewhere between 1.31 per cent and 11.6 per cent. Hurst, in reporting his experience in the medical wards of Guy's Hospital, found four deaths in a series of eighty-two cases of hemorrhage; a mortality rate of 4.8 per cent—which is well within the expected range.

We believe that the mortality rate reported in this paper is closely approximate although it does not actually represent the general mortality rate for gross hemorrhage from peptic ulcer. We have included only cases in which the diagnosis of gastric, duodenal or anastomotic ulcer was reasonably certain. We have included mild cases of gross hemorrhage as well as severe cases, but did not include any case that did not have vomiting of at least several ounces of blood or the passage of one or more definitely tarry stools. No case of occult bleeding alone was included. We did not include cases with a history of gross hemor-

rhage unless it occurred within six days before admission to the hospital. Our figures, therefore, represent the mortality of a group of patients who had the advantage of being treated in a hospital, but of course these figures must be interpreted in the light of certain factors which influence the type of case which comes to the Lahey Clinic.

In our opinion, the most useful clinical criteria in estimating the severity of a hemorrhage are the presence or absence of fainting, syncope or other symptoms of shock. The most dangerous feature of hemorrhage is the rapid decrease in blood volume. Patients who have a slow hemorrhage can tolerate a reduction of hemoglobin to a very low level, providing there is time for physiologic adjustment of the blood volume. Therefore, collapse, fainting and fall in blood pressure are indications of a hemorrhage which is of serious importance as compared to bleeding which does not cause such symptoms.

In the group we are reporting here there were 108 cases treated for acute gross hemorrhage, including duodenal, gastric and anastomotic ulcers. Of this group there were forty-seven mild cases and sixty-one severe cases. In the entire series of 108 cases, there were five deaths, a mortality of 4.6 per cent, and we believe this figure closely approximates the true mortality rate of gross hemorrhage due to peptic ulcer.

The treatment of bleeding peptic ulcer is one requiring considerable experience and a nicety of judgment in the handling of these cases. The problem of treatment is certainly not whether hemorrhage should be treated by medical or surgical methods, but is the determination of what system of management for each individual case will result in as few deaths as possible from this serious complication of ulcer. Unquestionably, there is a small group of patients with bleeding ulcers who must come to surgery and whom operation alone can save. However, it is our opinion that the majority of cases can be handled conservatively without the necessity of applying surgery.

The method employed in the Lahey Clinic in the conservative treatment of hemorrhage from ulcer consists of a régime which has been generally accepted and practiced for a number of years. It is essentially an expectant and conservative régime consisting of rest in bed, morphine in doses large enough to produce adequate sedation, starvation for two or three days and then a gradual application of the Sippy diet.

In recent years the most important new therapeutic measure has been blood transfusion, but there has been lack of general agreement as to its value. Many clinicians feel that there is a distinct danger in the giving of a blood transfusion on the basis that a possible rise in blood pressure may produce a blow-out of the thrombotic plug in the bleeding vessel, causing secondary hemorrhage.

In this clinic, blood transfusions have been used rather more freely than elsewhere for two distinct indications: first, to correct the acute loss of blood volume, and second, as a treatment of secondary anemia merely to shorten the patient's convalescence from a severe blood loss. Patients who die suddenly from the first outpouring of blood are rarely in the hospital and consequently the question of transfusion does not arise. The usual severe case of hemorrhage admitted to the hospital ward is the patient who has survived the shock of a severe blood loss, but who still presents the clinical picture associated with a marked reduction in blood volume below normal. Although life is being maintained, there are two distinct dangers associated with this condition. The first is danger of a secondary hemorrhage which in some cases is possible even though the blood pressure may be markedly lowered. If this occurs in the case of an already markedly reduced blood volume, the additional loss of blood may be suddenly fatal. The second and what is probably the most important danger, is the effect upon function and possibly irreparable damage which takes place in vital organs as a result of long continued reduction of blood pressure and

blood volume. One of the most outstanding laboratory evidences of this is the high nonprotein nitrogen frequently found associated with severe hemorrhage; this in some cases actually appears to be important in the cause of death. The brain, heart and liver are probably also affected, but this is not so easily demonstrated in the laboratory.

It would seem therefore that the danger of causing a secondary hemorrhage by giving a blood transfusion is distinctly less than the danger associated with letting the patient's condition remain at a low level too long. It has been our experience that a small or moderate size transfusion of citrated blood given slowly by the drip method has been safe and of distinct value. We have not seen a sudden rise of blood pressure following transfusions, but we have seen the gradual rise of blood pressure from a dangerously low level, that is below a systolic pressure of 90 mm.

The decision as to whether a transfusion is indicated or not cannot be based upon the examination of the blood count, since blood volume can be reduced to a dangerously low level without making an appreciable change in the red blood count or the hemoglobin determination. The changes in these values do not take place until after the blood volume has been at least partially corrected by dilution with body fluids. Clinical estimation of the patient's condition depends upon the pallor of the skin and mucous membranes, the rate and quality of the pulse and upon the blood pressure, with additional consideration given to the estimated quality of blood that has been expelled. No arbitrary rule can be followed, but a fall in systolic blood pressure to 90 mm. or below and a rise in pulse rate to over 130, particularly when there has been definite evidence of a large amount of blood loss, are indications for a transfusion.

The same criticisms may be applied to the use of intravenous and subcutaneous injections of glucose or saline solution. They are useful, however, when dehydration is severe and apparently they do allay



thirst to some extent during the starvation period. However, patients who are well morphinized do not complain much of thirst as a rule. If intravenous fluids are introduced slowly, the blood volume may be increased without appreciably raising the blood pressure, but on theoretical grounds at least, this is less desirable than by means of a transfusion since the viscosity of the blood is decreased and there may be a disturbance in the clotting mechanism brought about by the dilution.

Diet in the treatment of hemorrhage in peptic ulcer in this clinic and until recently generally accepted as a time honored method of treatment, consisted of starvation or the elimination of both food and water for a period before the gradual institution of the Sippy type of ulcer régime. In 1933, Meulengracht upset all previously conceived ideas as to the treatment of gastrointestinal hemorrhage by reporting that he obtained a marked reduction in mortality by beginning liberal and early feeding during or immediately after the bleeding. It was his opinion that early feeding preserved the strength and nutrition in a patient and brought about a more rapid convalescence and in this way reduced the mortality figure. He reasoned that the food had therapeutic value in neutralizing the gastric acid, thereby favoring healing of the ulcer and preventing digestion of the clot in the bleeding vessel. His diet consists of meat, fish, puréed vegetables, bread and butter, cheese, tea and cereals. In 1935, he reported 251 cases of hemorrhage taken to be due to genuine ulcer with only two deaths; a mortality of less than 1 per cent. He did not give his criteria as to the severity of the hemorrhages nor do we know from his report anything of the factors which might influence the relative incidence of severe and mild cases. He does compare his results with those of Christiansen and another hospital in Copenhagen, which appear to have an identical type of case and treated in the orthodox way. In this group there

was a mortality of 7.9 per cent in 289 patients.

Meulengracht's report has attracted wide attention and many clinics have modified their treatment of hemorrhage along these lines, but as yet there are few reports which give the results of any sizable series of cases. In the Lahey Clinic we have not yet changed over to the Meulengracht method of treating hemorrhaging cases, although in principle we follow his ideas to some extent. We do not starve the patients for any extended number of days, although it is our opinion that for forty-eight to seventy-two hours after a diffuse hemorrhage the stomach should be put at rest as nearly completely as possible. It is indeed a rare patient whose nutrition would suffer seriously from a starvation period of this length. If at the end of two or three days there is no evidence of a repetition of bleeding, it seems highly desirable to start therapeutic measures directed towards neutralizing gastric acidity, promoting healing of the ulcer. Although Meulengracht reported a 1 per cent mortality rate, it probably does not represent uniform results to be expected from this type of treatment. Yet, it is significant that he has observed a very definite and marked reduction in his mortality following this radical change in treatment.

Alkalis and other forms of anti-acid therapy should be used as in the routine management of an active ulcer. Starting the régime, however, it is necessary to observe precautions to avoid overloading the patient with too large a volume of food and medicine. The treatment of the secondary anemia should not be delayed, and the patient's convalescence can be hastened by the administration of sufficient iron. We have used chiefly ferrous sulfate in doses of 6 gr. three times a day.

Morphine is the drug most commonly used for sedation in dosages of  $\frac{1}{6}$  to  $\frac{1}{4}$  gr. every four hours, depending upon the quantity necessary to keep the patient immobile and asleep most of the time. The

patients who react to morphine with nausea and vomiting and nervous irritability may be given hypodermic medication of soluble barbiturates in dosages sufficient to obtain the desired results.

There has been some reported evidence suggesting a relationship between subclinical avitaminosis c and bleeding ulcer, but the importance of this relationship is still unsettled. In cases which show definite increase in capillary fragility above normal, vitamin c medication given parenterally would seem to be indicated. At present there is little evidence that the resistance of the blood vessels can be increased above normal by the administration of vitamin c. Furthermore, severe bleeding in peptic ulcer is not usually a capillary type of bleeding.

The use of hemostatics, vasoconstrictors and astringents has fallen into disrepute, and there is little on either theoretical or clinical grounds to support their use. The hemorrhage in peptic ulcer is not caused by failure of the blood to clot, but is due to the mechanical opening of the vessel. Furthermore, there is always the danger that the administration of such medication may cause vomiting or other disturbances which are distinctly detrimental to the cessation of bleeding.

Clinical decisions in any given case of severe hemorrhage must be based upon an estimation of the disease present, upon knowledge of all the factors which influence the prognosis and an accurate appreciation of just what can be accomplished in the way of treatment, whether it be medical or surgical. Nearly all of the severe and fatal cases of hemorrhage in duodenal ulcer occur from large posterior wall adherent ulcers with erosion of the pancreaticoduodenal artery. Hemorrhage which occurs in a long-standing chronic ulcer is apt to be serious since the abundant scar tissue interferes with the retraction of the eroded end of the artery. Large gastric ulcers situated on the posterior wall and eroding into the pancreas also give rise to the most severe type of hemorrhage. Hypertension

and arteriosclerosis are complicating factors which tend to aggravate hemorrhage. In hypertension the unduly elevated blood pressure may dislodge the clot repeatedly, and in arteriosclerosis there is loss of retractility of the vessel walls. The influence of sex and age upon the prognosis of gross hemorrhage has been repeatedly pointed out. Many authors have observed that the mortality in patients over the age of 45 or 50 is four or five times that of patients below this age. It has also been noted that women rarely die from hemorrhage in ulcer. In our clinic and in several other clinics, there has not been a fatality in women from such a cause.

Adequate and intelligent nursing care is essential to keep the patient at rest and to watch for signs of further bleeding. Hourly observations of the pulse rate and blood pressure are particularly useful. A sudden fall in blood pressure, a rise in pulse rate or other signs of collapse must be interpreted as indicating secondary bleeding even though there is no hematemesis or melena.

In our experience the occurrence of signs and symptoms indicating recurrent or secondary hemorrhage while the patient is on a complete hemorrhage régime is a serious omen and is an extremely important prognostic sign. When there is recurrent hemorrhage while under treatment, particularly if it is accompanied by signs of shock, it indicates that a large artery branch has been opened and that the retraction of the eroded ends of clot formation is inadequate. When this occurs in a patient who has had a long history of a severe ulcer, and who probably has a chronic indurated duodenal lesion, particularly in a male over the age of 50, the significance of this clinical course is emphasized.

When it is obvious with continuation of bleeding that a large artery is the source of hemorrhage or when continuous drip transfusion or repeated transfusion has failed to control the bleeding or to keep the blood pressure at a reasonable level it is then apparent that immediate operation may

prove to be necessary to prevent a fatal outcome.

The decision for employing surgery in a case of bleeding ulcer is a serious matter and requires the utmost coöperation between the internist and the surgeon. Certainly, early consultation between the internist and surgeon is a most desirable feature and it should be emphasized that this consultation should not be delayed until operation is recommended on the basis of a last desperate effort to save the patient's life. There can be no question that it would be distinctly wrong to advocate operation for the treatment of acute massive hemorrhage occurring from all gastric and duodenal ulcers. Should such a course be followed it would result in many deaths. We certainly would not advocate or recommend that all patients who have bleeding from peptic ulcers should have operation within forty-eight hours. For such a policy to become widespread or in general use as advocated by some surgeons would be serious indeed. Certainly such surgery should be carried out only by surgeons having considerable experience in gastric surgery and in large hospitals which are sufficiently equipped to permit emergency surgery of that character to be performed with reasonable safety. Furthermore, a sufficient number of donors should be at hand to provide any amount of blood that may prove to be necessary to the patient during such an operation.

Lahey has described two distinct types of acute hemorrhage occurring in patients with peptic ulcer and the recognition of these types has proved of great practical benefit to us in determining which case may possibly require surgical intervention. The first and more frequent type is that in which a single hemorrhage occurs, evidenced by the vomiting of blood or by passing a large tarry stool, in conjunction with varying degrees of shock. The hemorrhage may continue or may be repeated during the following twenty-four or thirty-six hours, but with the application of conservative medical measures the bleeding

ceases and does not recur. With this type surgery will not prove to be necessary.

There is another type of massive recurrent hemorrhage in which large amounts of blood are lost by vomiting or by stool, in which the hemorrhage is continued or repeated again and again on the same day or during the following days, in which serious blood loss is evident by a fall in blood pressure, which is uncontrolled by repeated blood transfusions or continuous blood drip. It is obvious that unless something can be done early a fatality will certainly result.

There is danger in delay in such a case, and it is generally accepted that the mortality in surgery mounts rapidly as the patient becomes more and more exsanguinated. If it can be definitely established that the patient is having recurrent gushing hemorrhages in spite of a complete and adequate medical régime, transfusions and operation should be done. It would be highly desirable if this type of patient could be operated upon within forty-eight hours of his first hemorrhage, but it is scarcely possible to do this in all cases and still allow time to determine whether or not he is having secondary hemorrhages. We cannot entirely agree with Finsterer, who is the chief advocate of surgical treatment for acute hemorrhage, in his practice of operating upon all patients who have passed middle age who have a severe hemorrhage, even though his reported mortality in early operations compares very favorably with the medical mortality in this group of cases. It seems very unlikely that Finsterer's low mortality rate of 5.1 per cent could be duplicated by more than a very few surgeons.

Such serious hemorrhages usually result from an erosion of the pancreaticoduodenal artery at the base of a penetrating ulcer of the posterior wall of the duodenum, or an erosion of the left gastric artery or of the gastro-epiploic artery in a gastric ulcer on the posterior wall of the stomach which may perforate into the body of the pancreas. This type of hemorrhage usually

occurs in a patient with chronic callous ulcer with rigid ulcer base. In the majority of cases the patient is a male over 50, with sclerotic arteries. Too early and ill-considered surgical interference in these cases cannot be too heartily condemned.

Surgical interference should be designed primarily to control hemorrhage and except in a few cases need not include removal of the ulcer or be designed to effect permanent cure of the ulcer condition.

If the patient's condition is such, if the experience at hand is sufficient and if the equipment is adequate to proceed with more radical surgery, we believe that removal of the ulcer with a high resection of the stomach of the Hofmeister type should be carried out. However, in conditions where such an extensive surgical procedure would be very likely to result in a fatality, a more conservative method of handling the situation should be employed.

Gastroenterostomy alone is not a satisfactory operation to control bleeding from an ulcer and is rarely used or advised. The effect of such a procedure in controlling hemorrhage is an indirect one because it presumably places the pylorus and duodenum at rest and permits continuous emptying of the stomach through the gastrojejunal stoma.

The majority of patients with severe hemorrhage requiring surgical interference will be found to have bleeding from arteries of large caliber such as the pancreaticoduodenal or other arteries which so abundantly anastomose about the head of the pancreas.

The type of ulcer which is associated with much induration, with extensive periduodenal adhesions, makes simple ligation of the main trunks of the arteries supplying the pylorus and duodenum a difficult and most uncertain procedure. (Fig. 1.) To ligate the right gastric artery or the gastroduodenal artery may not be sufficient to establish hemostasis and fatal hemorrhage may result from the numerous anastomoses of arteries about the head of the pancreas.

In the case of hemorrhage resulting from a duodenal ulcer, if the patient's condition does not warrant a removal of the ulcer,

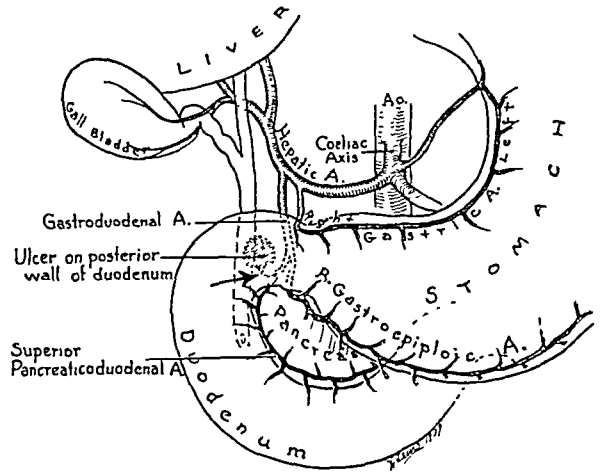


FIG. 1. The arterial blood supply of the pyloric area of the stomach and duodenum. The relationship of a posterior wall duodenal ulcer to large arteries is noted.

with a high resection of the stomach it is the practice of this clinic to proceed with a transduodenal ligation, with silk transfixion sutures, of the bleeding vessels and to accompany this procedure in most cases with a gastrojejunostomy.

The method of procedure is as follows: A high left rectus incision is made, of sufficient length to permit ready exploration of the upper abdomen. The situation of the ulcer which is the source of hemorrhage is readily determined in the majority of cases by examination of the stomach and duodenum. In an occasional case it may be difficult to determine the presence of an ulcer on the posterior wall of the duodenum and incision of the anterior wall of the duodenum may be required to demonstrate the source of the hemorrhage.

Should the blood be issuing from an anterior wall lesion, this would be obvious upon inspection and in the majority of cases such an ulcer can be excised by a longitudinal incision along the axis of the duodenum, extending through and above the pyloric ring; all bleeding points are ligated and a pyloroplasty is made by closing the incision transversely.

However, when the hemorrhage results from a deeply penetrating ulcer on the

posterior wall of the duodenum the superior and inferior borders of the duodenum and pyloric area are grasped by tacking forceps

area is closed transversely, thus performing a typical pyloroplasty. In the event of considerable scarring and contraction of

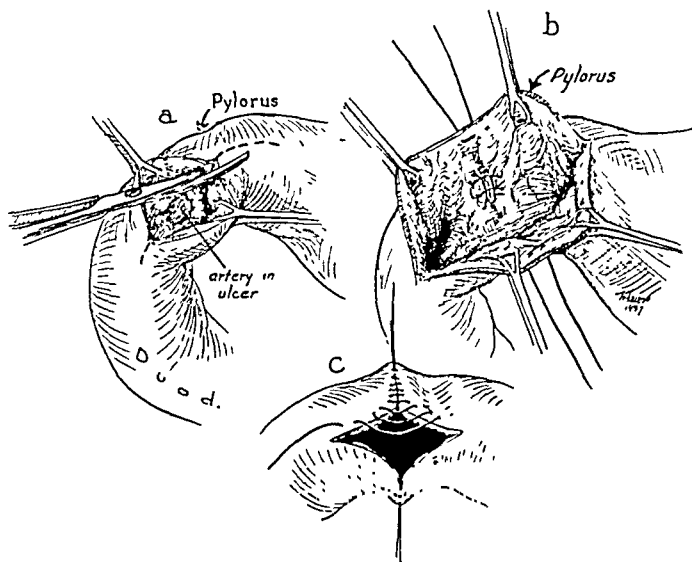


FIG. 2. Transduodenal ligation of bleeding vessel in ulcer on the posterior wall. *a*, incision opening the duodenum extended past the pylorus for about 3 cm.; *b*, mattress sutures of silk are introduced through the base of the ulcer to control hemorrhage; *c*, pyloroplasty performed by closing the incision transversely.

and an incision is made into the duodenum and extended above the pylorus for about an inch, opening the duodenum widely. The duodenum and stomach are aspirated to avoid spilling stomach contents, and the source of the hemorrhage can be easily determined. In most cases the blood will be seen to be issuing from an artery of large caliber at the base of the ulcer. The bleeding may then be controlled by mattress sutures of heavy silk introduced into the posterior wall of the duodenum (Fig. 2) and including the edges of the ulcer base. We advise the employment of a nonabsorbable material for this suture because with one patient we had recurrence of hemorrhage ten days after ligation, due to the digestion of the catgut suture material. In this case reoperation with removal of the ulcer-bearing area of the duodenum and a high resection of the stomach was completed, with recovery of the patient.

Following the ligation of the ulcer base the rent in the duodenum and pyloric

the duodenum with resultant narrowing of the lumen, a posterior gastrojejunostomy is always employed.

If, however, upon exploration examination of the stomach and duodenum discloses the hemorrhage to be issuing from a gastric ulcer on the posterior wall of the stomach which has penetrated into the pancreas, the stomach is freed from the pancreas and from the base of the ulcer, the bleeding vessels are ligated, the margins of the ulcer are excised from the stomach wall, and the rent in the stomach is simply closed by suture without gastroenterostomy. If the ulcer proves to be on the lesser curvature and resection is considered impossible because of the patient's condition, a simple excision of the ulcer with closure of the opening in the stomach is performed. In this event a posterior gastroenterostomy is always employed to avoid interference with gastric emptying.

However, if the patient's condition following massive blood transfusions before

and during operation permits resection of the stomach, we prefer to remove the ulcer, whether duodenal or gastric in origin, and proceed with a high resection, that is, removing with the ulcer three-fourths to four-fifths of the stomach and performing a gastrojejunostomy of the antecolic Hofmeister type. (Fig. 3.) It is evident that the conservative operative procedure such as outlined above may fail to relieve ulcer distress permanently, or prevent recurrent hemorrhage. Permanent relief is more apt to follow a high resection of the stomach with removal of the ulcer area, but this is not always possible because of the serious condition of the patient at the time that operation is carried out. Certainly if conservative operative methods are employed and if the patient has a recurrence of symptoms upon a good ulcer régime, a high resection of the stomach should be advised and carried out as early as possible.

In preparation for such an operation a method for infusion of blood into the patient to control blood pressure and partially to restore blood loss must be provided for. Immediately before operation a Hendon cannula is tied into the long internal saphenous vein in the ankle and during operation a continuous drip transfusion of blood is given. This method has proved thoroughly reliable and satisfactory.

The type of anesthesia employed in these cases is a regional block of the abdominal wall, obtained by infiltration with 0.25 per cent novocain solution, which may be supplemented if necessary with a light cyclopropane gas anesthesia. Cyclopropane gas oxygen anesthesia is of especial value to supplement regional block because of the high oxygen concentration (80 to 85 per cent) which may be desirable in view of the anemia resulting from blood loss. If the patient's blood pressure is controllable at a reasonable level by the rapid infusion of blood and his condition is reasonably good we prefer to employ a dilute nupercaine solution; 1:1500 dilution, as a spinal anesthetic. This form of spinal anesthesia can be safely employed in most patients

and is a much more adequate anesthesia in the event that a high resection of the stomach with removal of the ulcer can be used in the particular case.

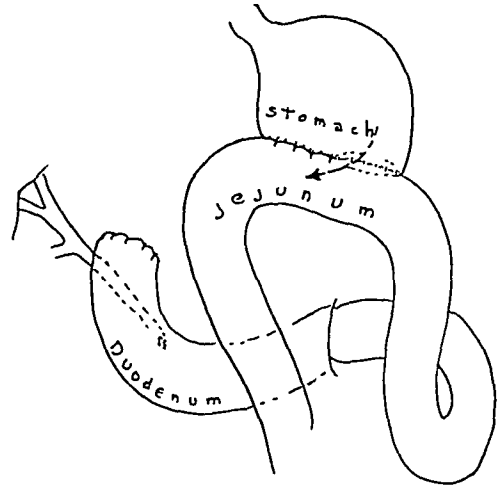


FIG. 3. Subtotal gastrectomy, Hofmeister method. The ulcer is removed and high resection of the stomach is done. The jejunum is brought anterior to the colon. The gastrojejunostoma is indicated by a dotted line. This is the operation of choice for bleeding ulcer if the patient's condition will permit.

#### SUMMARY

Acute massive hemorrhage from peptic ulcer is a serious complication, particularly in patients with chronic, callous ulcer.

In a series of 108 cases of massive hemorrhage of peptic ulcer in the Lahey Clinic, there were five deaths, a mortality of 4.6 per cent.

In the majority of cases the method of treatment employed in acute hemorrhage from peptic ulcer is a conservative régime consisting of rest in bed, morphine in doses large enough to produce adequate sedation, starvation diet for a few days, and then a gradual application of the Sippy régime.

Surgical management is employed in a very small group of cases in which there is continuous bleeding from an erosion of a large caliber vessel, uncontrollable by conservative measures.

The operation of resection of the stomach with the removal of the ulcer is the operation of choice, provided the patient's condition will permit it. If resection cannot be employed, a more conservative procedure

is followed, such as transduodenal ligation of the eroded vessel in duodenal ulcers, or an excision of a gastric ulcer, with or without a gastroenterostomy.

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MUCH of Galen's surgery was learnt on the battered bodies of gladiators, for their care was entrusted to him by the Pontifex of the Games in Pergamos. . . . As he gained experience of (tendon) injuries which were apparently very common among the gladiators in his charge, he began to suture the ruptured ends of the tendons in certain cases.

# STRANGULATED HERNIA

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ONE of the common causes of acute intestinal obstruction is strangulation of an external hernia. Since this condition constitutes a surgical emergency, its prompt recognition and a thorough knowledge of the principles of treatment should be a part of every surgeon's training.

While strangulation may complicate the rare or unusual forms of hernia, such as obturator, sciatic, lumbar and diaphragmatic, it is seen much more frequently in the commoner varieties, i.e., inguinal, femoral, umbilical and postoperative ventral.

*Diagnosis.* Except under unusual circumstances, the diagnosis is not difficult. In every case of suspected acute abdominal condition, especially if symptoms of intestinal obstruction are present, a meticulous examination of the external orifices should be made. This is imperative because, in addition to the symptoms common to intestinal obstruction from other causes, strangulated hernia presents a painful, tender, tense mass or swelling at the site of one of the external hernial openings. Not infrequently the patient is unaware of the existence of the hernia. This is particularly true of the femoral variety, although usually a previous history is obtainable.

*Pathology.* For the most part, hernial openings have a firm, fibrous, unyielding margin which may compress the imprisoned viscus. When the pressure is sufficient to impair the venous return, engorgement and further swelling rapidly supervene. Unless relieved, the blood supply is further impaired, necrosis becomes inevitable, and gangrene and perforation follow. The hernial sac becomes filled with a transudation which at first is blood-tinged and later frankly bloody.

Bacteria pass readily through the wall of the intestine during the later stages of this strangulating process so that the fluid may be turbid and cultures taken therefrom yield a growth of the *B. coli* group.

In addition to the local changes, a general abdominal distention results from the complete interference with the flow of the fecal current, and with the distention all the clinical manifestations of acute mechanical ileus are seen, viz., vomiting, toxemia, dehydration, and lowered plasma chlorides.

The mechanical effect of an acute partial enterocele, or Richter's hernia, is such that firm pressure cuts off the blood supply to only a portion of the circumference of the bowel (usually the small bowel) without obstructing completely the passage of intestinal contents and gas. Hence, such a condition may result in gangrene and perforation without the classic distention and toxemia which other forms of strangulation induce. This variety of strangulation is most often seen in femoral hernias when a small segment of the bowel is nipped by the particularly unyielding edges of the femoral ring. Where the contents of the sac consist solely of omentum, vomiting may be a symptom, but distention and toxemia are usually less prominent.

*Reduction en Masse.* This rare complication of strangulated hernia usually follows persistent and vigorous attempts at manual reduction. In a typical case, early unsuccessful efforts at reduction are suddenly followed by a sensation of "slipping back" of the hernia together with a disappearance of the mass. Instead of complete relief of symptoms, there is a persistence thereof, accompanied by concomitant signs of obstruction which become progressive. In such a case, laparot-



omy reveals an inverted sac which still constricts at the neck the segment of bowel. Since the obstruction persists, it is obvious that gangrene and perforation will follow unless relieved by prompt exploration. That this unusual condition is not often recognized and, therefore, has a high mortality rate is due to the fact that it is seldom suspected.

*Treatment.* Preventive treatment must be regarded as one of the practical ways in which a lowering of the mortality rate may be accomplished. In periodic health examinations, as well as in those made prior to employment, it should be the aim of the examining doctor to detect a hernia in its early stages and to recommend operative correction. It is unusual for a hernia to make its first appearance late in life, but procrastination or ignorance causes many individuals to encounter strangulation at an age when operation carries a greater risk.

Once the condition of strangulation has been recognized, valuable time should not be lost by attempts at manual reduction, for with each hour's delay the prognosis is adversely affected. Taxis is safely used only in cases seen early; in general, it is not to be recommended. The danger of reduction of a nonviable segment of intestine or the rare "reduction en masse" must be borne in mind.

*Operative Procedure.* The first aim of operative treatment is to release the imprisoned intestine (or other viscus) from its constriction. To accomplish this promptly and with as little manipulation as possible requires adequate exposure; consequently small incisions are to be condemned. After the sac has been opened and its contents inspected, one must decide whether or not the condition of the bowel will permit of its return to the abdomen. Here surgical judgment based on experience is essential. If the gut is lusterless, sodden, lacking in peristalsis and without pulsation of the mesenteric vessels, then exteriorization or resection is imperative. If, under the influence of warm, moist pads, the

dusky color changes to a more normal appearance, then it is viable and may safely be returned. In cases at either extreme, a decision is not difficult. In borderline cases, however, the decision may be a delicate one. In general, if after ten or fifteen minutes have elapsed, there is still a question in the mind of the surgeon, it is wisest to exteriorize the involved loop. Whenever during the preliminary stages of the operation, spontaneous reduction of the contents occurs before a decision as to their viability has been reached, it is advisable, after repair of the hernia, to perform an exploratory celiotomy and to scrutinize carefully the previously strangulated loop. If resection is necessary, it can then be performed far more easily and safely. This precaution is necessary to avoid perforation of the non-viable gut and ensuing peritonitis. As to whether exteriorization or resection is indicated, one must weigh the patient's chances of surviving secondary procedures if the former is chosen, against the greater risk of immediate resection in the presence of toxemia, distention and dehydration. If resection is decided upon, it is often best performed through a separate incision after the strangulation has been relieved.

Illustrating the problem of decision between enterostomy and resection, the following personal case is cited:

J. K., male, aged 48, a garage worker, was admitted to the Second Surgical Division, Bellevue Hospital on November 3, 1926, complaining of violent and persistent vomiting associated with cramp-like pains in the abdomen, and obstipation. Examination revealed a moderately distended abdomen, rather tender and tympanitic. There was generalized muscular rigidity, not board-like in character, however. In the right groin, apparently along Poupart's ligament, there was a globular mass vaguely outlined beneath the thick layer of fat. The mass was somewhat indurated and there was a faint pink blush on the overlying skin. It was not reducible, gave no impulse on coughing, and was exquisitely tender to palpation. During the examination the patient

vomited offensive-smelling brownish material in large amount.

Leucocytes numbered 25,350; polys 94 per cent, transitionals 2 per cent, lymphocytes 4 per cent. Urinalysis was negative except for two plus albumin. Temperature was 99 degrees, pulse 120, respirations 20.

An immediate operation was performed under 1 per cent novocaine anesthesia. A right femoral sac was exposed which, when opened, revealed a Richter's hernia in which about three-fourths of the circumference of the gut was markedly devitalized. On the contra-mesenteric aspect a greenish area of gangrene and softening was present. While there was no evidence of actual perforation, a distinctly foul odor was apparent when the sac was opened. This hernia represented a type that is often described as an acute partial enterocele.

An inguinal incision prolonged downward over the femoral opening was made and the subcutaneous fatty layers overlying the femoral sac were divided; the sac was exposed and opened. An attempt was made to draw down the bowel to inspect the gut above the point of constriction but this, even after Gimbernat's ligament had been divided, was unsuccessful, owing to the fact that the gut seemed to be on the point of rupturing. The inguinal approach was then resorted to, and with the peritoneal cavity opened, bimanual efforts to reduce the gut were successful. Because of the patient's critical condition, resection was not carried out. The gangrenous loop was sutured into the upper opening in the peritoneal cavity preparatory to drainage of the bowel. A rubber dam drain was placed in the lower angle of the incision leading to the site of the gangrenous femoral sac which was previously excised.

Less than twenty-four hours later, an opening was made in the loop of gut which had been brought outside the abdomen and catheters were inserted in both limbs of the U. A prompt and copious discharge of foul-smelling intestinal contents, followed by relief of distention and other symptoms of obstruction, took place. The abdominal wall quickly became excoriated and an area 7 or 8 inches in diameter extending up to the umbilicus was within a few days raw and exceedingly painful. Attempts to protect the skin with kaolin and glycerine pastes were unsuccessful, and the patient grew weaker through loss of nutrition due to the high position of the enterostomy. Therefore,

one week later, November 12, 1920, it was decided to attempt a closure.

By finger dissection, the loop of gut with its opening was easily freed from the adherent muscle circumferentially. Traction on the loop withdrew the gangrenous portion for a distance of 3 inches on the proximal side and 4 or 5 inches on the distal side. As this was insufficient on the proximal side to permit a suture resection, the involved section was excised and anastomosis by Murphy button was performed. After the button had been closed, a further supporting peritoneal layer of continuous plain catgut No. 0 was introduced to perfect the serosa-to-serosa approximation. The anastomosis was then pushed within the abdomen and a large Mikulicz rubber dam tampon was placed in the opening through the abdominal cavity and held by very carefully applied dressings maintained with many tail binders.

*Subsequent Course.* Following the second operation, the patient rapidly improved. There was no distention and the inflammatory condition of the abdominal skin rapidly yielded to treatment with zinc oxide ointment. The Mikulicz tampon was repacked daily and as the wound closed its contents of packing were reduced and finally removed. Granulations filled the area of depression and the wound healed.

*Pathologic Report of Femoral Sac.* The sac consisted of edematous fat and areolar tissue thickly infiltrated with polynuclear cells. The diagnosis was acute infiltration, fat and areolar tissue. A culture taken at operation was sterile after seventy-two hours.

This patient was lost track of after June 29, 1927, but at that time he was in excellent condition with no subjective symptoms.

#### TECHNICAL CONSIDERATIONS

*Anesthetic.* A local or a spinal anesthetic is desirable in adults. If a general anesthetic is used, the stomach should be emptied with a duodenal tube which may be left in place during the anesthesia period. If this precaution is neglected, the patient may regurgitate and inhale sufficient material to cause serious pulmonary complications; in extreme cases he may literally be drowned during the operation. For infants and young children we prefer open drop ether rather than local or

regional anesthesia. Avertin may be used as a basal anesthetic unless there are contraindications.

*Operation.* The primary aim of the operator is always to relieve the strangulation and to restore the viable contents to the abdomen as speedily and as gently as possible. To this end, a generous incision and rapid sharp dissection with a minimum amount of tissue trauma from rough handling are desirable. Provided the condition of the patient permits, repair of the hernia should then be carried out as meticulously as in a non-strangulated case. The additional time required for the repair itself should not exceed ten minutes.

*Femoral hernia repair* in cases of strangulation deserves special consideration. The operator should familiarize himself with the inguinal approach for femoral hernia because in strangulated cases this method is particularly important. The reasons are twofold: (1) it aids greatly in the reduction of the hernial contents and at the same time exposes them for thorough inspection as well as for rapid and safe resection if required; and (2) it enables the operator to repair the femoral opening by suturing Poupart's ligament to Cooper's ligament from above, thereby closing the opening from within. Most recent writers are impressed with the superiority of the inguinal or high approach especially as applied to operations for strangulated femoral hernia.

*Postoperative ventral (incisional) hernia* may, when strangulated, offer almost insurmountable difficulties. This is due principally to the extensive adhesions that may glue the loops of intestine to the interior surface of the sac as well as to each other. Patience and fortitude are often required for the successful performance of such an operation. It may be good judgment to relieve the constriction, reduce the contents attempting to free each adhesion, and close the abdominal wall as carefully and rapidly as possible. Even if every existing adhesion were faithfully divided, it is more than likely that many new ones would soon be formed.

*Inguinal Hernia in Infants.* Ever since Dowd (1898) reported a successful operation for strangulated hernia in an infant, at the same time alluding to previous cases collected from the literature, surgeons have recognized that there is no age limit to a favorable outcome. These little patients stand surgery remarkably well, provided it is done rapidly, gently, and with a minimal loss of blood. Early operation is of paramount importance; delay diminishes the chance of survival by almost geometrical progression. Small infants do not withstand well the prolongation of operating time incidental to enforced resections. It is axiomatic that an operation should be undertaken before a lapse of time results in the contents becoming non-viable.

*Sliding Hernia.* When, as rarely happens, a strangulated sliding hernia of the cecum or sigmoid is encountered, the operator is apt to become confused. Only infrequently is a satisfactory high closure of the sac obtained even when the Hotchkiss operation is employed to construct a new mesentery for the sliding component. In such cases, prompt cord division, as recommended by Burdick and Higinbotham, has in our hands greatly simplified the hernial repair. This can be made tight from one end of the inguinal canal to the other, thus compensating for the unsatisfactory disposition of the sac.

*Internal Hernia.* In contradistinction to the far more common instances of strangulation of external hernia, reference at least must be made to the rare varieties of internal strangulation, such as, hernia through the foramen of Winslow, paraduodenal hernia, pericecal hernia, intersigmoid hernia, obturator hernia, sciatic pudendal hernia. In general, these hernias are operated upon under the diagnosis of *intestinal obstruction*. It is most unusual for a correct preoperative diagnosis as to locality to be made. The surgeon, however, should bear in mind the possibility of a hernia occurring at any of these different locations and recognize it at once when encountering intestinal obstruction at lap-

arotomy. While it is not within the scope of this paper to discuss each of these various types of internal hernia, suffice it to say that early exploration and relief of the obstruction is the important desideratum.

*Enterostomy.* Exceptional cases seen late in the course of the disease, with frank gangrene and with the patient in a critical condition may require enterostomy. In these, the performance of resection and suture anastomosis is one which, while greatly to be preferred, is too formidable a procedure. It is better judgment to deliver the gangrenous loop outside the abdomen and to place rubber tubes in both limbs of the loop. Where small intestine is involved the resulting excoriation of the abdomen from irritating intestinal contents and the rapid loss of strength of the patient demand further attempts to close the bowel as soon as all symptoms of obstruction have been relieved. So manifold are the complications of a small intestinal enterostomy of this type, and so hazardous are the later surgical attempts to relieve it that one is justified in choosing resection at the original operation even when the patient's condition seems desperate.

*Postoperative Care.* If skill is required to bring the patient through the actual operation, it is also an important requisite in postoperative care. Distention and vomiting may occur, requiring gastric lavage or continuous duodenal suction by Wagensteen's method. The restoration and maintenance of normal levels of body fluids is a question of knowledge of the normal, and how to correct dehydration and the loss of sodium chloride and other important electrolytes. At the same time glucose must be supplied to afford caloric requirements until tolerance of the gastrointestinal tract has been reestablished.

Tympanites and serious ileus are prevented by the use of pitressin, as advocated by Potter, but the effect of this drug upon distention already present is less marked and is generally transient. During a stormy and prolonged convalescence, vitamin deficiencies must be combated. The work of Harvey and his co-workers on wound

disruption due to vitamin deficiency is particularly applicable to cases in which disruption would be of such serious consequence. Blood transfusion is a valuable supportive measure.

*Sequelae.* Recurrence of the hernia is not an infrequent sequel to an operation for strangulation. This may be due to the severity of the operation, to unavoidable damage to the tissues during attempts at reduction, and to the fact that in some instances the constricting band or ring may have to be divided. In inguinal or femoral hernia, damage to Poupart's ligament is a predisposing cause of recurrence. The patient's condition may enforce a speedy and less anatomic closure. Sometimes contamination of the sac by organisms transuded from the imprisoned loop will result in wound infection (the influence of the latter upon the recurrence-rate is well recognized).

Late stenosis causing an incomplete or chronic intestinal obstruction may be the ultimate fate of a loop of bowel which seemed somewhat questionable at the time of operation and was consequently returned to the abdomen. Garré (1892) and Maass (1895) first reported such cases. The latter explained the stricture formation as a result of necrosis of the mucosa; in this condition the stenosed area is found to be lined with atrophic and smooth mucous membrane.

Where only a very limited amount of intestine is involved, a tight stricture may be caused, the area being hard, pale, fibrous and lacking all semblance of intestine. Here, the bowel proximal to the stricture may become hypertrophied as well as dilated while distally it is collapsed.

Schmieden and Scheele ascribe the occurrence of this type of stricture, which is annular and slowly progressive, to thrombosis of the arteriole in the mesentery supplying that area of the intestine. Eising reports two such cases.

#### CONCLUSIONS

1. Strangulated hernia constitutes one of the most urgent of surgical emergencies.

Time is of the greatest importance, for the earlier the operation is performed the greater prospect there is of survival.

2. Taxis is generally unsafe and therefore to be condemned.

3. The diagnosis is not difficult if a careful examination is made of the sites of abdominal hernia in every case of suspected "acute abdomen."

4. Treatment consists of gentle release of the imprisoned contents and careful repair of the hernia.

5. Resection is advisable unless the viability of the involved intestinal loop seems definitely assured. When in doubt, it is wiser to resect.

6. If, during the operation, the imprisoned loop slips back before it has been thoroughly inspected, it should be exposed and its viability definitely ascertained even if a laparotomy is required in order to gain access to it.

7. Attention must be paid to restoration of fluids, chlorides and glucose by venoclysis during the immediate postoperative period.

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# RUPTURE OF THE BLADDER AND ACUTE RETENTION OF URINE\*

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## RUPTURE OF THE BLADDER

**R**UPTURE of the urinary bladder is relatively infrequent, largely due to the fact that this viscus is carefully and securely placed in the depths of the bony pelvis where it is inaccessible to trauma except for the most severe crushing injuries to the pelvis or trauma associated with more or less extensive distention of the bladder.

This series of cases is from the Urological Department of the City of Detroit Receiving Hospital for the three year period ending May 31, 1939.

The infrequency of this injury is shown by the fact that for the period above mentioned there were in three Detroit hospitals with 137,661 admissions only eleven cases.

1. City of Detroit Receiving Hospital with 63,154 admissions, had ten cases of rupture of the urinary bladder.

2. Harper Hospital with 53,137 admissions, reported one case of rupture of the urinary bladder.

3. Children's Hospital of Michigan with 21,370, reported no cases of ruptured bladder.

Dr. Francis W. Hagner, in the first edition of Cabot's "Urology," quotes at length regarding the frequency of rupture of the urinary bladder, bringing the literature down to 1918.<sup>1-4</sup>

The writers he cites call particular attention to alcoholism as the contributing factor and all show a terrific mortality. Later, Keane<sup>5</sup> reported a series of cases

showing a mortality similar to that noted by earlier reporters. Three of his cases were gunshot injuries with complicating multiple intestinal perforations. Six did not come to surgery until twenty-four or more hours after injury. All observers have noted that the mortality rate mounts with the hours of delay following injury. The points to be noted are the rather low social status of the individuals and the intoxication present. These observations are borne out in our experience. In the series of ten cases at the Detroit Receiving Hospital seven of the individuals were alcoholic and had been drinking recently, thus having more or less distended bladders at the time of the injury.

The symptomatology is sometimes varied and indefinite but frequently a tentative diagnosis can be made from the history and the clinical findings confirmed by: (1) catheterization with injection of small amounts of saline solution which cannot be recovered; (2) cystography—intravenous urography; (3) cystoscopy.

All these patients had a more or less acute retention of urine, either complete or a slight dribbling of a few drops of bloody urine. The symptoms depend in large part on the time element involved. In early cases there is shock, with urinary retention, low abdominal tenderness and fulness. Late cases may present the picture of peritonitis.

Catheterization may show a small amount of very bloody urine or a large amount of blood-stained fluid, the latter if the

\* From the Department of Urology, City of Detroit Receiving Hospital, Services of Drs. W. E. Keane, H. W. Plaggemeyer and the writer. Thanks are extended to the resident staff, Dr. Linus W. Hewit and Dr. Elwood A. Jenkins, for assistance in the preparation of this material. Unless otherwise mentioned, cases presented are from City of Detroit Receiving Hospital.

catheter passes through the laceration into the abdominal cavity.

Cystography or intravenous urography

fatal cases there were, in addition to ruptured bladder, multiple fractures including severe skull fractures. In one case

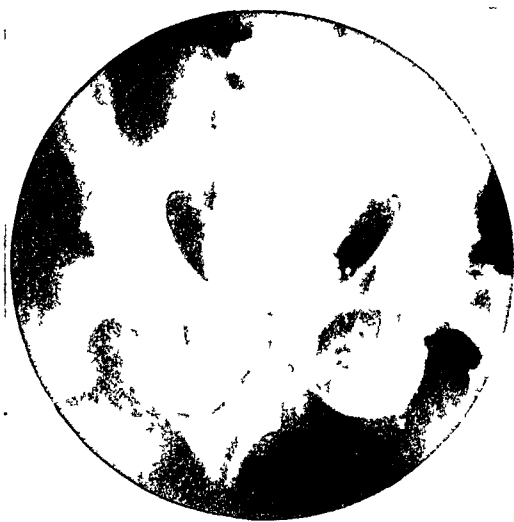


FIG. 1. Male, age 40. Spontaneous rupture following vigorous attempt to void after a "beer party." The man stated that after severe and prolonged straining in efforts to void he suddenly had the sensation of something giving way in his abdomen. Operation thirty-six hours after rupture, with suture of laceration and suprapubic drainage and peritoneal drainings because of intraperitoneal abscess. Recovery. Note tip of catheter in the abdomen.



FIG. 2. Female, age 3. Struck by automobile. Fractured pelvis, sacrum and femur. Extraperitoneal rupture and extravasation of urine and blood into pre- and perivesical spaces. Suprapubic cystotomy and drainage of perivesical area. Recovery.

show extravasation of the contrast medium either into the abdomen or laterally along the abdominal wall, depending on whether the laceration is intra- or extraperitoneal.

Cystoscopy may show the tear in the bladder wall or may be absolutely valueless owing to inability to distend the bladder or to the fact that the beak of the cystoscope may be lost among the coils of the intestines.

The diagnosis in most of these cases was established by the house staff before the patients were seen by the attending staff. In most of the cases of this series, cystograms were made which either made or confirmed the tentative diagnosis of rupture of the bladder. Sodium iodide (15% solution) was used as the contrast medium. Air may also be used.<sup>6</sup> We have found that cystograms apparently do no damage whatsoever as all but two of our patients made satisfactory recoveries. In the two

the diagnosis was made without cystogram and in the other with the aid of cystogram.

Cystoscopy may be of value and was diagnostic in one of the series. However, I feel that one should not add the trauma of cystoscopy to the shock already present until all less rigorous procedures have been exhausted.

Treatment in these cases has been surgical—open operation—as soon as the patient has sufficiently recovered from shock to permit operation. Some of these patients have been so severely shocked that several hours elapsed before operation could be undertaken. The shock is combated by the usual methods of heat, morphine, blood transfusion, intravenous glucose and saline.

A low midline incision is made and the muscles separated. The entire pre- and perivesical area is usually found to be infiltrated with blood, which obliterates landmarks. The bladder is generally collapsed and in an attempt to pick up the bladder wall with Allis forceps the peritoneum may be opened. This is of no

moment as it should later be opened for inspection in any event to determine the presence of intra-abdominal injury. The laceration is located and closed trans-vesically or, if this is difficult, the closure may be made from the peritoneal side. Both procedures are equally satisfactory.

In some of these cases it was felt that peritoneal drainage was necessary because of the length of time before operative interference, and in one case because of rather extensive infection from the extravasation of urine into the abdominal cavity. All patients had suprapubic drainage for a week or ten days, following which a urethral catheter was substituted and the suprapubic sinus closed.

Briefly reviewing this series of cases (Figs. 1-3), it will be noted that:

1. Seven of the ten were alcoholic.
2. Diagnosis was made with the aid of cystograms in seven of the cases.
3. Cystogram seems to have no injurious effect or interrupt the recovery in any way.
4. There were two deaths, both in individuals with multiple fractures, including skull fractures.
5. The age incidence, with one exception, was in the third, fourth, and fifth decades.
6. Operation was done from four hours to six days after injury. Contrary to all accepted precept, the individual operated on six days following the rupture made a rather uninterrupted recovery.
7. In one case a gunshot injury had caused two small pellets to lodge in the bladder. These were removed cystoscopically. The other patients were dealt with by open operation.
8. Two of the cases were extraperitoneal ruptures; seven were intraperitoneal ruptures.
9. One case occurred in another hospital. This was an industrial accident and in addition to the rupture of the bladder there was rupture of the urethra, multiple fractures of the pelvis and other injuries resulting in death. (Seen with Dr. A. C. Hall.)

## CONCLUSIONS

1. Rupture of the urinary bladder is uncommon.
2. Early diagnosis is essential to proper treatment and satisfactory result.
3. A preoperative diagnosis can usually be made.
4. Uncomplicated ruptured urinary bladder seen early and dealt with surgically early, does not carry the high mortality mentioned by earlier writers.

## ACUTE RETENTION OF URINE

Acute retention of urine may be met with in and is frequently due to:

1. Acute infections—general sepsis, typhoid fever, pneumonia, etc.
2. Ante- and postpartum urinary tract infection.
3. Spinal cord lesions (lues, tumor, meningitis, poliomyelitis, trauma).
4. Vesical neck obstruction—adenoma and carcinoma of the prostate—fibrosis of the bladder neck.
5. Urethral stricture—inflammatory or traumatic.
6. Rupture of the urethra:
  - A. Pendulous.
  - B. Bulbomembranous; anterior to urogenital triangle, varying with laceration to complete severance associated with the fracture of the pelvis.

As the subject of this symposium is Emergency Surgery, it has seemed advisable to eliminate such cases as are amenable to management with the soft rubber catheter and limit the scope of the discussion to such cases as require immediate surgical intervention either with special urethral instruments or with open operation, such as perineal section or suprapubic cystotomy.

The acute infections and urinary infection in pregnancy and the puerperium may therefore be eliminated except where organic lesions of the urethra prevent the passage of an ordinary soft rubber catheter.



Spinal cord lesions, in the absence of organic lesions of the urethra or bladder neck such as stricture or prostatic obstruc-

and dangerous to the prostatic, without the risk of "poking holes" in the prostatic urethra.

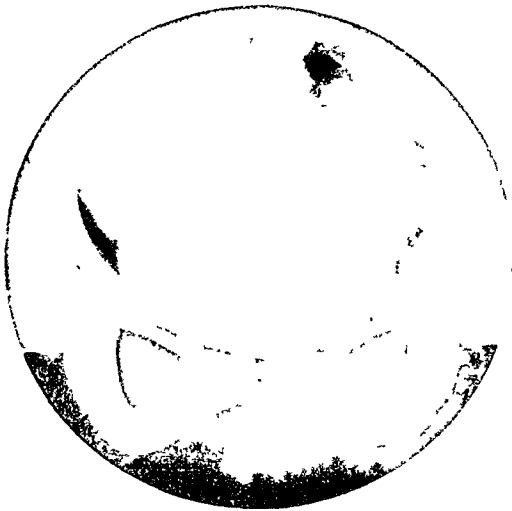


FIG. 3. Female, age 34. Kicked in abdomen in drunken brawl. Suprapubic cystostomy. Suture of laceration. Drainage of peritoneal cavity. Recovery. Note extravasation across lower abdomen extending well up to the right.



FIG. 4. Type of pelvic fracture producing varying degrees of laceration of prostatic urethra with extraperitoneal extravasation of urine and hematoma, as shown in Figures 5 and 6. The displaced fragment produces a shearing or tearing (partial or complete) of the prostatic urethra. Figures 2 and 6 are cystograms in cases of extraperitoneal rupture of the bladder but show the urinary extravasation and hematoma found in rupture of the prostatic urethra. A urethral catheter drained blood and urine. At operation the tip of the catheter passed out through the laceration in the prostatic urethra. Seen with Dr. J. A. Smith.

tion or obstruction due to acute trauma, may also be eliminated from the discussion as ample time is provided for study of methods of dealing with this type of case (attempts to produce an automatic bladder, suprapubic cystostomy or inlying catheter<sup>7,8,9</sup>). The management of this type of case is highly controversial and is a chapter by itself.

Vesical neck obstruction in which no type of catheter can be introduced into the bladder leaves no choice but a suprapubic cystostomy or a suprapubic stab with a trocar and introduction of a drainage tube after the method of Lower.

All attempts to catheterize these old and often greatly debilitated prostatics should be made with the utmost gentleness. A metal catheter may easily produce a false passage through the obstructing prostate with resulting hemorrhage, infection and pelvic cellulitis, and for this reason is considered a very dangerous instrument and should rarely, if ever, be resorted to. A suprapubic cystostomy is much less shocking

Impassable stricture of the urethra may be either inflammatory or traumatic. Here again, the utmost gentleness is necessary. Filiform bougies and followers may be tried. If there is some dribbling of urine and *no evidence of urinary extravasation*, attempts to pass an instrument through the stricture may be repeated before resorting to surgery. If one is fortunate enough to pass a filiform bougie through the stricture it should be tied in, regardless of how tight it may seem to be. Regardless of the snug fit in the stricture, the patient will be able to urinate around the bougie. The stricture may be so tight that the smallest follower cannot be passed through it. However, after twenty-four to forty-eight hours, a small follower may frequently be attached to the filiform and passed without difficulty

During the past four or five years at the City of Detroit Receiving Hospital there has been only an occasional external ure-

and subsequent dilatation carried out. If the stricture is still impassable an external urethrotomy may be done. This (external

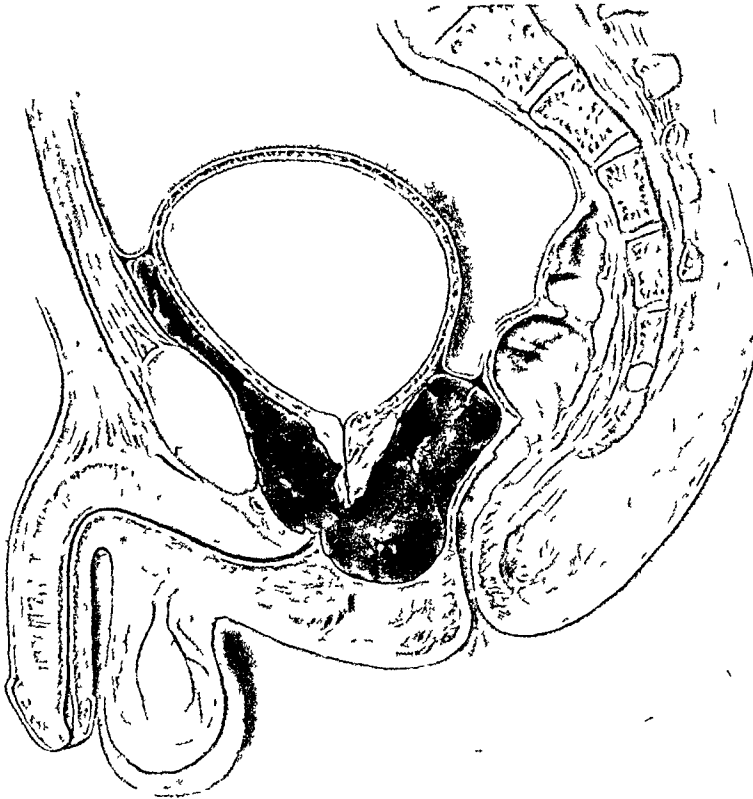


FIG. 5. Schematic representation of extreme degree of extravasation following rupture of urethra posterior to triangular ligament. Shows why inlying catheter may drain urine but still not drain the bladder and demonstrates the necessity of suprapubic cystotomy. Also shows necessity of perineal drainage.

throtomy for stricture. Most so-called "impassable" strictures have been sufficiently relaxed under spinal anesthesia (general anesthesia apparently does not produce relaxation). Practically all of the strictures have been dealt with by dilatation without urethrotomy. On my own service in the last five years, we have not had more than a half a dozen external urethrotomies for stricture and in all of these there were complicating perineal sinuses. The remainder of the cases were dealt with by dilatation.

In case the stricture cannot be managed by dilatation, a suprapubic cystotomy can always be done. Drainage for a week or ten days quite frequently relieves the edema and swelling in the stricture sufficiently to permit a filiform to be passed

urethrotomy without a guide) should be attempted only by one experienced in perineal surgery.

In connection with the treatment of acute retention of urine due to impassable stricture of the urethra, the problem of extravasation of urine must be considered. This type of case is rarely seen in private practice but is almost invariably observed in the large municipal hospitals. Most of them occur in broken-down, debilitated patients who are bad surgical risks from the beginning.

At first sight, suprapubic cystotomy with a diversion of the urinary stream would seem very inviting, but all too frequently the extravasation and infection have extended up to the abdomen, so that in doing a suprapubic cystotomy one must go

through an infected area into the prevesical space with its extensive blood supply. Thus infection is almost deliberately car-

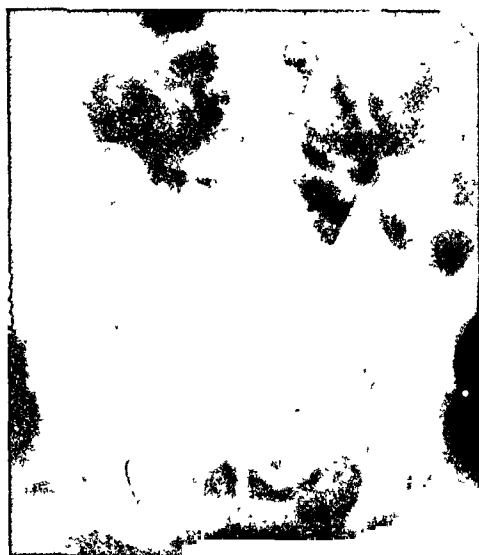


FIG. 6. Female, age 50. Extraperitoneal rupture of bladder with extensive extravasation of urine following low abdominal trauma. This shows type of extravasation in extreme degree met with in rupture of urethra posterior to triangular ligament. This case was in a female and shows the antero-posterior view of the extravasation seen in ruptured urethra in the male shown schematically in Figure 5. In the male with rupture of the prostatic urethra, the extravasation and hematoma are much deeper in the pelvis and may require dependent drainage through the perineum. Note in Figure 5 the ease with which perineal drainage of the cavity can be carried out. Also, it shows the applicability of drawing the proximal and distal portions of the urethra together with a pilcher or Hagner bag after the method of Ormand and Cothran.<sup>16</sup>

ried into the prevesical space, often leading to general sepsis and death. Wide multiple incisions through the area of extravasation with excision of necrotic tissue should be carried out. Either a catheter is passed through the rupture in the urethra behind the stricture on into the bladder for drainage, or the patient is permitted to urinate through the ruptured urethra into the dressings. The mortality in this type of case is high, due in part to the debilitated condition of the patient and in part to the extent of the infection.

A rupture of the pendulous portion of the urethra is rare, seen only in the severest

type of crushing or grinding injury involving the penis or in cases of trauma to the erect organ as in drunken debauches, etc.

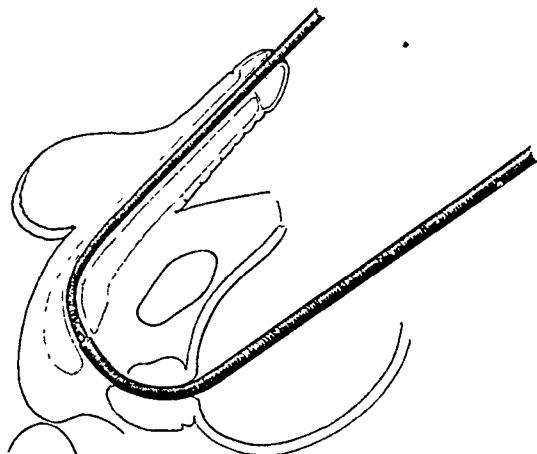


FIG. 7. Schematic representation of Davis<sup>14</sup> procedure of passing a sound through a ruptured urethra. If Davis instruments with male and female tips are not at hand, ordinary urethral sounds may be used.

Herman<sup>10</sup> calls the attention to a case of a fracture of the pendulous portion of the urethra and notes that this type of rupture usually is the result of direct trauma of the organ against the female pelvis. A similar but less complicated case came to the writer's attention some years ago, acquired as described by Herman, in which there had been a fracture of the erect penis with considerable bleeding. The patient came under observation some years after the injury and there was a marked stricture of the pendulous urethra which did not respond well to dilatation.

In this type of case, probably the best procedure is to pass, or attempt to pass, a soft rubber catheter through the lacerated portion of the urethra into the bladder to maintain drainage and at the same time splint the urethra, maintaining patency until healing has taken place. If this measure is unsuccessful a suprapubic cystotomy should be done.

Rupture of the bulbomembranous portion of the urethra is due almost invariably to "straddle" injuries, kicks, or other direct trauma to the perineum. This type of injury is seen in a lad who is walking a fence and falls astride; also in industrial workers,

sailors, or riggers who fall astride a beam or some such object or in an individual stepping on a loose "manhole" cover, as described by O'Connor.<sup>13</sup> Aside from the immediate shock accompanying the injury, usually there is bleeding from the urethra together with acute urinary retention. In late cases there may be extravasation of urine into the penile and scrotal tissues.

Attempts to pass various types of urethral instruments are usually unsuccessful and such being the case, unless one is adept in perineal surgery, an immediate cystotomy should be carried out. Even then it is a debatable point whether to attempt an immediate repair of the contused and lacerated urethra or to drain the hematoma and carry out the repair a few days later, applying the procedures described by Cabot<sup>11</sup> and MacGowan.<sup>12</sup> After opening the bladder an attempt may be made to maneuver an instrument through the lacerated urethra after the method described by Davis.<sup>14</sup> (Fig. 7.) A sound is introduced through the urethra to the point of laceration and a second sound through the cystotomy wound and then through the posterior urethra until the two meet. The anterior sound will follow the posterior sound into the bladder, after which a catheter may be attached to the beak of the anterior sound and drawn through the urethra and anchored, furnishing an internal splint for the urethra.

These patients should not be dismissed until they are thoroughly impressed with the fact that for the rest of their lives they are somebody's patient. According to the dictum of Keyes, they should report to their urologist for dilatation on New Year's Day and the Fourth of July.

Rupture of the prostatic urethra is a complication of fracture of the pelvis and occurs through the bladder neck, through the prostatic urethra or at the apex of the prostate, and is due to a shearing or tearing through the urethra by the displaced fragments of bone. (Fig. 4.) Spicules of bone may also penetrate the bladder. This laceration takes place behind the triangular

ligament and extravasation of blood and urine is pre- and perivesical. These patients come to the hospital in more or less shock, unable to void, with some bleeding from the urethra, and marked fulness and tenderness over the suprapubic area. Usually there is a "doughy" feel in the suprapubic region. Attempts to catheterize are usually unsuccessful but occasionally a catheter will pass and withdraw bloody urine. This may be due to the fact that the catheter passes out through the laceration of the urethra into a hematoma or an area of extravasation of urine in the pre- or perivesical space. Figures 2, 4 and 6 show pre- and perivesical extravasation of blood and urine.

In view of these findings there is no choice other than immediate suprapubic cystotomy with evacuation of any hematoma and drainage of the perivesical area. The area of extravasation may be so deep in the pelvis that adequate drainage can be attained only through the perineum. With the bladder opened, procedures for maintenance of the continuity of the urethra may be carried out.

The laceration of the urethra may vary from a tear to complete severence. (Fig. 5.) Here again the procedure of Davis<sup>14</sup> may "turn the trick" or in the instance of complete severence the procedure devised by Ormand and Cothran<sup>16</sup> of attaching a Hagner or Pilcher bag to the urethral sound and drawing the tube through the urethra as in the introduction of the bag in prostatectomy, will draw the proximal and distal ends of the urethra together. Young<sup>15</sup> reports a series of cases in which repair was carried out by the perineal route.

It is important to note that in a large percentage of these cases injury involving the prostatic urethra causes impotence, probably due to damage to the blood or nerve supply, and perhaps partially to nerve damage of or interference with the blood supply of the penis. This factor of impotence is a matter of importance from a medicolegal standpoint and from the standpoint of responsibility for subsequent

neuropsychiatric disturbances. Both the patient and the employer should be informed that the patient is to be under somebody's care indefinitely and must have periodic dilatation of the urethra to maintain patency and prevent subsequent stricture formation. Considerable stress has been placed on this necessity for prolonged observation where the bulbous and prostatic urethra is involved, as the writer's cases of this type have been industrial accidents subject to the workmen's compensation laws. Some of these patients refused to follow instructions and a few years later appeared with complications which caused the employers great annoyance and expense.

#### CONCLUSIONS

1. Urinary retention due to impassable stricture and urethral trauma demands immediate intervention.

2. Over-enthusiastic instrumentation may produce varying degrees of trauma with hemorrhage and sepsis.

3. Delay may lead to urinary extravasation.

4. These cases must report at regular intervals for urethral dilatation in order to prevent recurrence of the stricture.

5. The most important *don't's* appear to be:

A. Do not over-instrument an already damaged urethra.

B. Do not delay surgical intervention.

In connection with delay, William J. Mayo<sup>17</sup> writing editorially on perforation of an abdominal viscus, says "the risk of immediate operation may be relatively

small and responsibility must rest on those who caused delay," and quotes John B. Murphy as saying, that one must "get in quick and get out quicker." These sayings are most applicable in the management of ruptured bladders and acute urinary retention.

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# ECTOPIC PREGNANCY\*

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**E**CTOPIC pregnancy whether recognized before, during, or after the act of rupture always demands prompt surgical intervention. Associated with the three anatomic types indicated are different signs and symptoms, and each of the resulting clinical groups should be discussed separately. This plan simplifies comment upon the task, difficult at times, of accurate differential diagnosis, a cardinal requirement of competent treatment.

## DIAGNOSIS

It is almost impossible to differentiate a case belonging to the first group, before rupture, from an early uterine pregnancy. A sausage-shaped, unilateral mass in the position of a tube suggests the correct diagnosis, but many an over-enthusiastic surgeon has found, at operation, a normal pregnancy with a large corpus luteum at the tip of an elongated ovary. Howard Kelly used to tell of having seen Dr. B. C. Hirst, an exceptionally qualified gynecologist, carefully inspect both tubes at a pelvic operation, and then have one rupture three weeks later!

Definition in the second group rarely, if ever, proves difficult. A former teacher of mine was fond of repeating his belief that the policeman on the beat could diagnose accurately a ruptured tubal pregnancy. The classical picture is that of a young woman, usually with a history of amenorrhea, stricken suddenly with abdominal pain, collapse, and more or less vaginal bleeding. Oftentimes in this group abdominal pain radiates to one or both shoulders, indicating intraperitoneal hemorrhage.

With respect to management this group does not follow the surgical rule, that shock whenever present must be treated before

operation. Here, shock is apt to progress steadily until the hemorrhage has been controlled; therefore, immediate laparotomy becomes advisable. The patient, if at home, should be given morphia in adequate dosage to relieve anxiety and pain, and removed at once to a hospital, preferably on a stretcher.

Most surgeons feel that the intravenous administration of fluids is contraindicated until after bleeding has been controlled, as treatment which raises blood pressure tends to increase hemorrhage. However, exceptions occur to every rule, and we have all seen cases in which preoperative blood transfusion, intravenous glucose in saline, or gum acacia solution, has unquestionably saved a life. Depending on the degree of circulatory failure, the transfusion will be given just before, during or after the laparotomy; but never given until the surgeon is ready to operate.

In this group the extent of the operation should be limited to the control of bleeding, which requires, of course, adequate removal of all pathologic tissue. For example, one of the patients in our series, in shock, was operated upon for right tubal rupture. Right salpingectomy was performed, without removing a cornual wedge. Eighteen months later she returned for consultation, having missed two periods, was admitted to the hospital and discharged after five days with a diagnosis of intrauterine pregnancy. Four months later on account of low back pain she came to the out-patient x-ray department. There she suddenly collapsed and was rushed to surgery, where a ruptured right interstitial pregnancy was found in the portion of the tube left at former operation. Such accidents, however, do not challenge the truth that the margin

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of operative safety is narrow in the presence of shock; unnecessary procedures then become hazardous. The death of a patient in our series occurred at the outset of the operation, just as the peritoneum was opened.

In the third group, the chronic stage of tubal pregnancy, diagnosis becomes difficult. The differentiation here includes unilateral ovarian cysts, fibroids, unilateral inflammatory masses, pregnancy, retained secundines, and appendicitis. Probably accurate diagnoses are made in no more than a third of these cases. After studying such problems as they often present we may have to content ourselves with the remark that "tubal pregnancy must be considered." If it is found, do we hesitate to take credit for a correct diagnosis? Not often. On the other hand, many of these bold assertions are hidden away in the histories of patients who actually turned out to have suffered from one of the other possible disturbances mentioned above.

Among the cases included in this report shock was present in eighty-one instances at the time of operation. Sixty-three of these patients were operated upon immediately after admission; the remaining eighteen had been in the hospital for a varying length of time, with the diagnosis in doubt, and the situation became clear only when shock developed. Certainly these patients were favored by being in the hospital at the time, but delay in diagnosis appreciably increased the surgical risk involved.

To evaluate various diagnostic points, we have studied the histories of the ectopic pregnancies operated upon at the Los Angeles General Hospital between 1932 and 1937, a series of 319 cases. Fourteen of the women had successive tubals; and these "repeats" have been included, as they presented a different clinical picture in each of their two experiences.

#### DEATHS

A short summary of the fatal cases is pertinent.

#### CLINICAL DATA FROM 319 ECTOPIC PREGNANCIES

Age			
Below 20 Yrs.	20-30 Yrs.	30-40 Yrs.	40 Yrs. and Over
13	164	115	13
Parity			
Nullipara	1-4 Pregnancies	5 Pregnancies or More	Not Stated
60	194	45	20
White Blood Count			
8,000 or Less	8 to 12,000	12,000 to 20,000	20,000 and Over
64	71	101	48
Red Blood Count			
Over 3,500,000	Under 3,500,000		
119	159		
Hemoglobin			
Over 70 Per Cent	Under 70 Per Cent		
117	165		
Sedimentation Time			
Over ½ Hour	Under ½ Hour		
105	30		
Blood Pressure			
Over 100	Under 100		
188	99		
Friedman Test			
Positive	Negative		
41	20		

Shock. 81. On Admission 63. After admission 18.

	Per Cent
Irregular bleeding	204 61
Amenorrhea..	180 56
Fainting.....	116 35
Shoulder pain...	74 23
Painful defecation	27 9
Attempted abortion.	16
Repeated admissions	20 6
Appendectomies ...	28 9 (3 acute)
Deaths.....	5 1.5
Peritoneoscopy.....	11
Colpotomy.....	11
Curettements before admission . .	7
After admission...	4
Autotransfusions....	122
Tubal rupture right .	81
Left.....	80
Tubal abortion right .	59
Left .....	59
Unruptured tubal pregnancies	24
Abdominal pregnancies	8
Cornual pregnancies .	5
Interstitial pregnancies . . . . .	3
Preoperative Stay in Hospital	
2-7 Days	1-2 Weeks Over 2 Weeks
53	25 28

#### Postoperative Stay in Hospital

Less than 2 Weeks	2-3 Weeks	Over 3 Weeks
218	69	27

CASE 1. Age 21, gravida 0. W.B.C. 8200, Polys 70 per cent. R.B.C. 3,300,000. Hgb. 70 per cent. B.P. 110/70. The period was three weeks overdue. A positive Friedman was reported five days after admission. Six days later the patient went into shock. Double salpingec-

tomy and left oöphorectomy were performed. Death occurred twelve hours later. Autopsy showed a bleeding vessel at the site of operation.

CASE II. Age 37, gravida vii. W.B.C. 22,300. Polys 91 per cent. Sedimentation rate 13 minutes. R.B.C. 1,890,000. Hgb. 30 per cent. B.P. 130/80. The patient had missed two periods. Three days before admission she fainted three times. She was admitted to the medical ward, and after forty-eight hours was transferred for immediate operation. Left salpingectomy was done and death occurred on the seventh postoperative day from paralytic ileus.

CASE III. Age 30, gravida v. W.B.C. 15,500. Polys 86 per cent. R.B.C. 3,460,000. Hgb. 75 per cent. B.P. 130/70. This patient had missed a period, and eight days before admission she had a sudden pain in the left lower quadrant and fainted. She had been bleeding slightly since. She fainted again on the day of admission. Operation was done under spinal anesthesia four hours after admission. Respirations ceased as the peritoneum was opened.

CASE IV. Age 28, gravida v. W.B.C. 14,700. Sedimentation rate 30 minutes. R.B.C. 1,740,000. Hgb. 35 per cent. B.P. 92/55. The patient had had a scant period and had bled for three weeks. A diagnosis of tuberculous salpingitis with possible intrauterine pregnancy was made and operation was carried out twelve days after admission. A right unruptured tubal pregnancy was found. Hysterectomy and double salpingectomy were done. The patient died on the sixth postoperative day. Autopsy showed extensive pulmonary tuberculosis.

CASE V. Age 30, gravida ii. W.B.C. 3,350. Sedimentation rate 12 minutes. R.B.C. 3,730,000. Polys 72 per cent. For one month the patient had had amenorrhea. She then began to bleed and kept up for a month until her admission. A catheter was used before admission. After pelvic examination the pulse went to 136, and the patient was in severe shock. She was rushed to the operating room, where a ruptured right interstitial pregnancy was found. Hysterectomy and right salpingectomy and oöphorectomy were done. Autotransfusion and 450 c.c. whole blood failed to help and the woman died three days later. Autopsy showed acute pulmonary edema.

#### CLINICAL STUDY

Farrar has concluded that the white count rises shortly after hemorrhage, and

drops later. Most of our cases, having only one count, showed a slight increase in leucocytes. A slow sedimentation rate pointed to ectopic in distinction from pelvic inflammation. A low red count and low hemoglobin suggested hemorrhage.

The fact that there were twenty negatives out of sixty-one Friedman tests has great practical significance. This valuable test is not infallible, as a recent case of mine bears witness. The woman 32 years old had had light radium treatment for metrorrhagia six months before. Following the use of radium there were four months of amenorrhea; then bleeding resumed and gradually increased, until she was brought to a neighboring suburban hospital. During the week she remained there she was twice curetted and was given two blood transfusions, and her uterus was packed on two occasions. The day she was transferred to our hospital the Friedman test was reported positive. At operation we found engorged tubes and free pus in the cul-de-sac from which *Streptococcus hemolyticus* was cultured. On the seventeenth day after operation she died of streptococcic peritonitis.

Peritoneoscopy, a useful diagnostic measure, gave a correct diagnosis in ten out of eleven cases in which it was employed. The case erroneously reported as an ectopic showed massive hemorrhage from a ruptured follicle, and required an immediate laparotomy.

Colpotomy was used eleven times, with one mistake. In that instance a straw colored fluid drained out, a finding upon which we based a diagnosis of intraligamentary cyst. At operation, however, nine days later, an ectopic pregnancy was found.

In the differentiation of ectopic from threatened abortion or retained secundines, curettage may be very useful. If decidua without chorionic villi is obtained, the diagnosis of ectopic is justified. Unless fetal parts, or obvious retained placental fragments are recovered, the surgeon should await the microscopic report on



the tissue. In our series curettage was done only four times, and as it happened the information obtained was not helpful.

Our statistics emphasize the diagnostic importance of irregular bleeding, amenorrhea, fainting and shoulder pain. The incidence of painful defecation was only 9 per cent. Pain of some kind, to be sure, is ordinarily the reason why a woman with an ectopic pregnancy seeks professional advice. But the descriptions of pelvic pain in the histories I have reviewed were too vague to permit accurate classification. None the less, complaint of pain radiating to one shoulder or the other has appeared so often that its importance as a pathognomonic symptom must be stressed.

Autotransfusion was used in 122 cases, over a third of the series. When there is no evidence of infection, whatever free blood the peritoneal cavity contains should be citrated, strained, and returned to the patient through a vein in one of the extremities.

Ludwig reported a series of 145 ectopic pregnancies in which sixty-three appendectomies were done. Among our patients twenty-eight appendices were removed, twenty-five chronic and three acute, of which one was ruptured. The convalescence was not noticeably affected in any of these

cases. It is noteworthy that an operation for a gangrenous appendix was performed on one patient two years after a salpingectomy for chronic tubal pregnancy. We do not advocate appendectomy routinely, but the appendix should always be inspected, and whenever it is pathologic it should be promptly removed.

#### SUMMARY

1. Ectopic pregnancy always merits prompt surgical treatment, and this becomes imperative in case of tubal rupture.
2. Intravenous medication will be wisely postponed until the preparations for operation have been made.
3. The Friedman test, negative in 33 per cent of the cases in this series, is much less reliable with ectopic than with uterine pregnancy.
4. A great many ectopic pregnancies show neither amenorrhea nor irregular uterine bleeding.
5. In the event of active bleeding, surgical procedures should be limited to control of hemorrhage with adequate removal of pathologic tissue.

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# SALPINGITIS AND PELVIC CELLULITIS\*

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A DISCUSSION of the inflammatory diseases of the female is found in the writings of the ancients. Dr. Howard A. Kelly<sup>1</sup> has said "The history of the treatment of pelvic abscess is fraught with the deepest interest, for it exhibits in miniature all the phases of the growth of gynecology at large."

Due to lack of understanding of the pathology of pelvic infection, the earliest attempts in treatment were represented by extreme conservatism. Not until the early part of the nineteenth century was any attempt made to evacuate pus, when Récamier (1830-1840) practiced vaginal puncture and drainage. This was before the days of anesthesia, a decade before Marion Sims popularized the vaginal speculum, and thirty years before Lister applied to surgery the principles of Pasteur.

Récamier made few records, leaving to his pupil, Bourdon, the inspiration to carry on this simple and earliest operation for the treatment of pelvic infection. In 1886 Saroyenne advocated the use of a spear pointed trocar, dilatation of the drainage tract to admit two fingers, and the insertion of a two way rubber tube with daily irrigations of the abscess cavity.

With the advent of abdominal surgery by Lawson Tait in 1880, an actual view and understanding of the lesion was obtained for the first time, and there developed a period of radicalism, shocking to those who had practiced conservatism. By the year 1890, though a relatively high mortality accompanied this method, the abdominal route had been adopted in many clinics as the best way of treating most cases of inflammatory disease of the pelvis.

There followed in 1890-1891, a short period of ultra-radicalism, unscientific and extreme, in which vaginal panhysterectomy was advocated by Peon and Segond. In a condition clinically characteristic of large pelvic abscesses which might be mistaken for malignant tumors, hard, nodular and adherent, Peon performed vaginal panhysterectomy. When the uterus could not be removed in toto he dug it out piecemeal, controlling the bleeding by clamps left in place for forty-eight hours, irrigation being started on removal of the hemostats.

The method of Peon met with little favor; even Segond, his admirer, could not view the operation with complete approval. It was never widely accepted, and came gradually into limited use.

From 1890 to 1892 the opinion of groups or schools was divided as to which of the three methods was suitable: vaginal drainage, laparotomy with extirpation of the adnexa, or the vaginal hysterectomy of Peon with removal of the tubes and ovaries. There were strong advocates of each.

In September, 1892 the first International Congress of Gynecologists and Obstetricians met in Brussels. Representatives from practically all the European societies and from America were present. One of the chief subjects for discussion was the treatment of pelvic suppuration. The first paper was by Segond who advocated the operation of Peon, in all cases in which the lesion was bilateral. He admitted, however, that though the operation had greatly enriched the gynecologic repertoire, it should not be used exclusively. Peon, who was in the chair, supported his own work. Travers of London expressed the

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views of most British surgeons by urging laparotomy. Goullioud of Lyons spoke in favor of the method of his master, Laroyenne, saying, however, that he had been using more radical operations when drainage through the vagina had not been curative.

Each of these methods contributed to the knowledge of the subject. The outcome of the discussions was that the individual case called for a selected treatment, and Sanger of Leipzig put it aptly when he remarked that there were many roads that led to Rome.

Controversy continued, and American literature was replete with articles on operative procedure, containing, however, a scarcity of discussion on indications for operation. Henrotin of Chicago defended vaginal drainage, and condemned radical procedures. Joseph Price of Philadelphia, Franklin Martin of Chicago and Howard A. Kelly of Baltimore, pioneers in abdominal surgery and gynecology, advised salpingectomy. These men were the outstanding contributors who added largely to the clarification of pelvic infection.

Today with a better understanding of the nature and pathology of pelvic disease, treatment is again conservative. Gynecologists are agreed that almost without exception the acute infections are to be left strictly alone.

The most frequent source of pelvic infection is gonorrhea. According to Curtis,<sup>5</sup> the gonococcus is the responsible organism in from 70 to 80 per cent of all cases of salpingitis, the tubercle bacillus in 5 per cent, followed by the streptococcus, staphylococcus, and colon bacillus. Puerperal sepsis accounts largely for the presence of these latter organisms. Intra-abdominal lesions, not mentioned by Curtis, play a part. Graves<sup>7</sup> wrote years ago that tubal infection following appendicitis had not been sufficiently emphasized. Rubin<sup>13</sup> has called attention to the number of cases of sterility due to closure of the tubes from this cause.

Rarely does an infection of the tubes follow immediately a primary gonorrheal urethritis or endocervicitis. Invasion may result from instrumentation and improper treatment, or at any time during menstruation when the cervix is soft and the canal open, suitable media being offered by menstrual blood. Invasion beyond the internal os is rare in children or in women past the menopause since menstruation does not occur. Rubin, as quoted by Curtis,<sup>5</sup> has shown that women who menstruate at infrequent intervals show a lessened incidence of tubal infection.

Often months or years intervene between the initial infection and tubal involvement when, either from reinfection or from awakening of a chronic infection, the tubes become involved.

There has been much discussion as to why gonorrheal salpingitis undergoes complete recovery in some cases, while in others it becomes chronic, although exacerbations may be frequent. Curtis<sup>6</sup> in 1921 undertook a study of this problem, using inflamed tubes which he ground and cultured. He reported as positive only nineteen in 192 cases and believed that the micro-organisms were rapidly killed by means of a bacteriolytic process, and were rarely recoverable later than two weeks after the disappearance of fever and leucocytosis. Curtis' work has been extensively quoted. Studdiford<sup>14</sup> writes that the only dissenting opinion has been by Wagner, who in 1925 stated that in his opinion "the repeated flare-ups which are typical of gonorrheal salpingitis suggest that the organisms do not entirely disappear from the pyosalpinx even though they cannot be demonstrated in culture."

Taking cultures from tubes and ovaries, Studdiford, by means of improved culture methods, found that in twenty-four patients suffering from salpingitis 66.6 per cent harbored gonococci in spite of the fact that in none of them was the disease in the acute stage. In one patient it seemed likely that the most recent infection was ten years previous. Nineteen were regarded

as subacute and from them thirteen positive cultures were obtained. Two were classified as acute exacerbations of chronic salpingitis, and both gave positive cultures. Three were called chronic or healed and one of these gave a positive culture.

Studdiford's important contribution necessitates a revision of previously accepted ideas regarding reinfection as compared with recurrent salpingitis.

Originally both tubes are always infected. One may heal completely or one or both proceed to further destructive changes. At first a simple endosalpingitis, as the disease progresses, it becomes more purulent in type; the tubes lose their cilia and the rugae become ulcerated and glued together. The walls are thick, with involvement of the muscularis and subserosa. Due probably to retraction and agglutination, the ostia become closed with concomitant closure of the tubal isthmus, and a pus sac is formed which may reach considerable proportions. Because of its weight, the tube, bent on itself, gravitates usually to the posterior leaf of the broad ligament: it may, however, adhere to the large intestine, abdominal wall, or bladder. There is an associated inflammation of the pelvic peritoneum, of the external lining of the ovaries, and of the subperitoneal cellular tissue, especially that between the leaves of the broad ligament.

Attachment of the fimbria to the ovary is another means of tubal closure. Because the dense albuginea is resistant to invasion, the ovary escapes with only a superficial infection. With the rupture of an underlying corpus luteum, however, infection enters the substance with destruction of a considerable part of its tissue. As the abscess grows the sac composed of tubal wall and stretched out ovarian tissue gives rise to a tubo-ovarian abscess. Though both ovaries are extensively involved and permanently damaged, menstruation continues.

It was formerly thought that a hydrosalpinx represented the end result of a tubal abscess, and that the enclosed pus

had become gradually converted into a clear fluid. As quoted by Graves,<sup>7</sup> Menge first pointed out and Norris believes that a hydrosalpinx results from a mild inflammation which closes both ends and allows the collection of a serous fluid within the tubal lumen. Other causes are an inflammatory process arising outside the tube, a perisalpingitis from appendicitis, tuberculosis, or puerperal infection, and pelvic tumors, especially myomata.

Infection of the isthmus of the tube with the formation of palpable nodules, gonorrheal isthmica nodosa, is a form of salpingitis often overlooked at operation. Surgeons frequently amputate the tube, leaving the interstitial portion. This would be removed by a wedge-shaped piece of tissue in the cornua. Leaving the isthmic portion may give rise to continued infection, abscess, or even endometriosis. Nodules in this area are occasionally seen in tuberculous salpingitis.

All cases of gonorrheal salpingitis are accompanied by a certain degree of pelvic peritonitis which in rare instances, more commonly in children, may become general. With destruction of peritoneal epithelium and consequent gluing together of contiguous surfaces, the adhesions formed are at first light and easily separated. In the course of time they become firm and unyielding. They are seldom as dense, however, as those from a tuberculosis or streptococcic infection.

The treatment of pelvic inflammatory disease varies, depending on whether the disease is encountered in the acute or chronic phase. In acute cases there is a marked tendency for spontaneous remission of symptoms and pelvic findings, and operative treatment is not necessary. Therapeutic adjuncts have been sought which would hasten this resolution, such as, foreign protein injections, local heat therapy, fever therapy, and bactericidal drugs.

Foreign protein injections have been used on the basis that they promote antibody formation as well as give a febrile

reaction which has a bactericidal effect on the causative gonococci organisms. It is a clinical observation that frequently the most severe types of acute salpingitis show the greatest subsequent restoration of the pelvic organs to normal. Since these acute cases are accompanied by high fever, it has been argued that in the relatively afebrile case foreign protein stimulation is of benefit. The results are difficult to judge because of the natural tendency of the acute stage of the disease to regress, and the impossibility of differentiating between exacerbations and reinfections in the future. Also foreign protein therapy is usually combined with other forms of treatment such as bed rest and local heat. The most convenient forms of therapy consist of intramuscular (hip) injections of boiled skimmed milk and intravenous injections of typhoid vaccine. Commercial foreign protein preparations are available but are more expensive. An occasional patient will be found allergic to milk; and as a precaution against violent reactions from the typhoid vaccine administration, this foreign protein should only be given when the patient has been hospitalized. Nonspecific protein therapy is not devoid of danger as has been emphasized by Hektoen,<sup>9</sup> and by Bernstein and Ginsberg.<sup>2</sup>

Similarly, local applications of heat have been used in conservative therapy. Elliott treatments which consist of running heated water through a distensible rubber bag inserted intravaginally have been extensively used. Local heat applied to the vagina is not conducted more than a few millimeters beyond the mucosal surface, but does increase the blood supply to a greater depth and also soothe the pain, probably acting as a counterirritant. This treatment is entirely nonspecific, the heat being insufficient to kill the gonococci, but the treated patients note alleviation of pain and it has been a clinical observation that there is a more rapid resolution of the adnexal masses. Elliott treatments require careful supervision over the heat control mechanism. The bag filled with water

at 110°F. is distended to one or two pounds pressure and the temperature raised gradually to 130°F. The degree of distention of the bag is quite as important as the degree of local heat—some patients cannot tolerate adequate distention of the bag. Burns of the vaginal mucosa have been noted. The Elliott treatments should not be given when the vaginal discharge is copious as in early postpartum cases or at the time of menstruation. Occasionally in acute cases of pelvic cellulitis, such as those found postpartum, or postabortal, and accompanied by a considerable degree of fever, the Elliott therapy acts as an irritant, causing pain and more fever. Elliott therapy is best used after the acute stage is over.

Fever therapy, using the heat cabinet, is a form of treatment in which cures up to 80 per cent or higher are reported. Under the able direction of Dr. Franklin Ebaugh of the Colorado Psychopathic Hospital, there were treated from the Gynecological Service nine cases of pelvic abscess. In all but one patient who had us discontinue the treatment because she could not tolerate it, the mass completely disappeared or was quickly reduced in size. Symptoms and fever responded promptly. In one case, an intra-abdominal mass, a mixed infection of several weeks' duration with loops of intestine and brawny induration of the abdominal wall and underlying viscera, was opened twice. No pockets of pus were encountered. Under fever treatment, drainage stopped, the wound closed, and the patient remained well. Of twenty-nine cases of acute salpingitis, all responded well as regards symptoms, pain, and fever. Four showed positive smears immediately following treatment, nineteen were negative, of six there is no report.

In spite of good results, heat treatment should not be recommended without careful consideration as it is not without danger. Apprehension, restlessness, confusion, delirium, convulsions, calcium tetany, and drop in blood pressure, as well as a severe neuritis later are complications.

It is so disagreeable that many patients object to a second treatment. Most careful and skilled management is necessary.

It is now universally accepted that gonorrhea responds to sulfanilamide therapy. Pain and fever disappear within a few days, the discharge decreases, pelvic masses become smaller or completely disappear within ten to fourteen days. Complications are rarely seen. The drug has a definite effect in the control of acute and subacute salpingitis. Long and Bliss<sup>11</sup> observed seven cases of gonococcal peritonitis treated without surgical intervention, all of which did well under large doses of sulfanilamide.

There is no universal agreement as to the amount of dosage, but to maintain a certain blood concentration sulfanilamide should be administered at four hour intervals. Four to 5 gm. per day for the first week and then about 3 gm. a day for two weeks are suggested, maintaining a blood level of 5 to 7 mg. per cent during the treatment. Others suggest lower doses, 40 gr. of neoprontosil, which is less toxic, though not so powerful as sulfanilamide. Bicarbonate of soda is given in conjunction and nicotinic acid will lessen the toxic effects of sulfanilamide-containing drugs.

It has been the experience of all who have used sulfanilamide in gonorrheal salpingitis that pain, fever, and masses disappear; the gonococcus can, however, in many instances be recovered from the cervix, urethra, Skene's or Bartholin's glands after the treatment is stopped. It is obvious that individuals free from discharge, who believe themselves cured, are asymptomatic carriers and have the potentialities of a great social menace. This would apply to other forms of treatment as well, but sulfanilamide, because of its lethal properties toward the gonococci offers a better chance of cure than other methods of treatment.

Pronouncement of a cure in women is more difficult than in men. Frequent examinations, made preferably immediately after or during menstruation, are

necessary. Jones<sup>10</sup> noted that following treatment with sulfanilamide there are marked changes in the morphology and staining properties of the gonococcal organism. One should remember also that culture studies are much more reliable than those from microscopic smears.

Carpenter with co-workers<sup>3</sup> has shown that with cultures from the lower genital tract in suspected cases the incidence of proved gonorrheal infection has been raised almost 200 per cent. They use a technique of inoculation of a specially prepared blood agar plate incubating at 34°C. and 37°C. in an atmosphere of air reinforced approximately to 10 per cent in its carbon dioxide content. Cultures show that many patients considered free from infection still harbor the organism.

A frequent complication of gonorrheal salpingitis is pelvic abscess. Pus gravitates into the Douglas pouch and is walled off by omentum, loops of intestine, tubes, ovaries, and uterus, or a large pus tube or tubo-ovarian mass behind the uterus becomes fixed to the surrounding tissues. Such a mass made up of a single cavity or multiple abscesses may reach enormous size. Soon, through extension from the intestine, there is invasion of colon bacilli, streptococci, and anaerobic organisms. Such accumulations of pus respond poorly to non-operative procedures, though they may evacuate themselves spontaneously through the vagina or rectum. Operation, drainage, or removal by laparotomy is usually required.

Pelvic abscesses from postabortal or postpartum infection are next in frequency. The tendency of this variety of infection is to invade the parametrial tissues and form broad ligament or retroperitoneal abscesses. This type will be mentioned later.

The acute appendix is not an uncommon source of pelvic peritonitis and abscess. Norris<sup>12</sup> has emphasized the frequent association of appendicitis with pelvic peritonitis. The appendix is often found secondarily involved in a pelvic mass as a periappendicitis, or rarely it may undergo

suppuration. Coopman, as quoted by Wharton,<sup>1</sup> in 1915 stated that appendiceal involvement in cases of chronic purulent pelvic inflammatory disease in itself justifies laparotomy. Acute gonorrheal tubes are occasionally encountered during an operation for appendicitis. Though the convalescence may be somewhat shortened by their removal, such tubes should be left as infection will subside.

Pelvic abscess following ruptured ectopic pregnancy or postoperative accumulations of blood are encountered. Infrequently tuberculosis, carcinoma of the cervix, infected ovarian cysts, or uterine myomata are a cause.

Given a pelvic mass that can be drained by the vaginal route, a careful vaginal and rectovaginal bimanual examination is of prime importance in establishing the relation of the abscess to the uterus, bladder, broad ligaments, and rectum, determining at the time the most easily accessible and dependent part as well as any point of fluctuations.

Making an incision through the posterior vault of the vagina close to the cervix, a blunt instrument, dressing forceps or a curved clamp is now used to open the peritoneum. Some recommend previous exploration with a large bore needle. Having opened into the abscess, accessory pockets are felt for with the finger and punctured, with care not to break up adhesions which wall off the abscess from the general peritoneal cavity. In dealing with a gonorrheal abscess, soiling the peritoneal cavity is not regarded as serious; in the puerperal or pyogenic type, however, if the peritoneum is opened, the opening should be freely enlarged and thoroughly drained: a small hole is more dangerous than a large one.

It is unwise to explore the pelvis indiscriminately, and it is a safe rule that if a mass cannot be punctured easily it is better left alone. Openings into the general peritoneal cavity, the rectum, or bladder are dangerous complications.

The abscess cavity is drained by a hard rubber drain sewn to the vault. Irrigation

of the cavity is inadvisable because of the danger of soiling the peritoneum. The drain remains in place for seven to ten days depending upon fever and the amount of drainage. Approximately one-fourth of the patients with pelvic abscess are permanently cured by drainage and an equal number are partially relieved; the remainder, because of adhesions, distortion of pelvic organs, continuance of pain and discomfort, and residual infection, seek surgical relief.

Chronic pelvic inflammation is a disease of great clinical significance. It is of wide occurrence with varied and far reaching constitutional results. The pelvic organs are dislocated and immobilized. Menstrual disorders, dysmenorrhea, menorrhagia, and metrorrhagia are not uncommon. Pain in the lower abdomen, on one or both sides, continuous or frequent with short intermissions, made worse by exertion; interference with intestinal function through adhesions, with indigestion, and constipation; backache, fatigue and nervousness are sequelae.

Rest, hot douches, local heat, the inductotherm, and diathermy are forms of beneficial therapy, but often the patient is so incapacitated that surgery is necessary. This is either radical or conservative; various problems present themselves which are to be solved by the experience and ingenuity of the operator. Surgeons differ considerably in their ideas as to when to be conservative. Each case must be decided on its individual merits.

It is generally recognized that final clinical and pathologic results of conservative operations are not so good in the percentage of cures as are properly performed radical operations. Adhesions reform, raw surfaces are not so easily peritonealized, and resected ovaries too frequently cause ovarian dysfunction.

Unless they are irreparably damaged, there are just objections to the removal of pelvic organs in the younger individual. Loss of sex feeling, mental depression, and

lack of proper adjustment are of greater importance than residual pain.

Pelvic cellulitis is a different type of infection from that ordinarily seen in gonorrhea. The extraperitoneal connective tissue is invaded by pyogenic bacteria traveling along the lymphatics, usually a direct extension from the uterus or cervix, resulting most commonly in postpartum or postabortal infections. There are other etiologic factors, such as postoperative infection, carcinoma, stem pessaries; in rare instances the antecedent factor is not discoverable. The common site is the fibrous tissue between the layers of the broad ligament, "parametritis." Though most often unilateral, it may spread widely, surrounding the rectum, neck of the bladder, extend upwards to the iliac fossa and perinephritic regions, or downward into the rectovaginal septum.

Such an infection may resolve or proceed to abscess formation pointing to the inner-side of Poupart's ligament anterior to the bladder, or along the posterior abdominal wall between the iliac crest and the last rib. Ischiorectal abscesses may form through the parametrial infection passing between the fibers of the levator ani muscles. Spontaneous rupture of these abscesses into the bladder, vagina or rectum is occasionally observed.

Symptoms of pelvic cellulitis—fever, pain and tumor—are varied. Fever is usually present. Pain, likewise, usually a prominent symptom, may be only a discomfort. Diarrhea and urinary frequency occur from involvement of these viscera in the infection. At times the only prominent sign of pelvic cellulitis is a tumor in the lower abdomen which usually represents involvement of one or both broad ligaments.

The diagnosis of pelvic cellulitis is made by pelvic examination, particularly rectal, which reveals induration in the base of the broad ligament with or without extension to other areas. Differential diagnosis is difficult inasmuch as complaints are of little value, the history often unknown or unreliable, and the pelvic findings may

simulate closely those of intraperitoneal infections, carcinoma of the pelvic organs or bowel. Often one hesitates to diagnose pelvic findings as pelvic cellulitis until a definite etiologic factor is elicited.

In unrecognized or neglected patients with pelvic cellulitis, constitutional signs of loss of weight, anemia, and weakness appear. In the more virulent types there may occur associated septicemia, peritonitis, or thrombophlebitis. The termination may be fatal. Pulmonary emboli are encountered even in the comparatively milder cases.

Treatment is largely expectant. Surgery is to be avoided other than to evacuate pus. Incisions are to be made extraperitoneally where the pus commonly points; this is most frequently either above the inguinal ligaments or in the posterior fornix (vaginal approach). The method of approach through the groin was apparently first described by Hegar<sup>8</sup> in 1881 and was soon recognized and accepted as a valuable means of reaching the infection and staying outside the peritoneum. Recalling the spread of the infection, incision and drainage may have to be performed in other areas such as the flank, over the ischiorectal area, and occasionally over the femoral space. Laparotomy is to be avoided because of danger of soiling the peritoneal cavity with virulent pyogenic organisms which cause this type of infection. Resolution occurs most frequently without pus formation and is materially aided by bed rest and local heat. Transfusions are of considerable help when the patients are run down. Antistreptococcic serum has been advocated. More recently sulfanilamide has been used, particularly in postabortal or puerperal infections before parametrial infection has had an opportunity to arise.

In the treatment of puerperal sepsis due to hemolytic streptococcus, sulfanilamide has been exceedingly effective. When it is administered at the first sign of the disease Colebrook and Purdie<sup>4</sup> have shown that further spread of the infection is infre-



quent; that in 100 cases there was parametrial invasion in but five, and this small in amount. Another striking effect of the drug was its effect in the treatment of bacteremic cases. Fifty-three per cent recovered, and also three cases of general peritonitis.

Bacteriologic study of these cases makes it evident that the chances of a puerperal infection being of hemolytic streptococcal origin are very great. Ninety-two of 106 patients showed Lancefield Group A organisms, susceptible to sulfanilamide, two showed Group B, two Group C streptococci, and four Group G organisms.

Long and Bliss<sup>11</sup> state that there is experimental evidence from work on mice that sulfanilamide is fairly effective on Group C, only moderately so on Group B, valueless in sepsis caused by staphylococci or the anaerobic streptococcus, but excellent in Welch bacillus infections.

Colebrook and Purdie, as quoted by Long and Bliss<sup>11</sup> in a report of cases from Queen Charlotte's Hospital, showed that the average fatality rate of cases of hemolytic streptococcus septicemia had been 71 per cent during four years prior to the use of prontosil, while in the fifteen months in which the drug had been used the death rate was cut to 27.3 per cent.

If seriously ill, large doses of sulfanilamide are given, with a blood concentration of 10 to 15 mg. per cent; mild cases without bacteremia or peritonitis are given smaller doses, cutting the drug down one-third or one-half after symptoms subside, and the temperature has been normal for two days. Smaller doses are then continued for a few days longer.

It has been noted that the offending organism may be recovered from the genital tract for a considerable time after all treatment has been discontinued.

In an established case of cellulitis the usual response with conservative management is gradual improvement. The fever disappears, the pain is less, and the general condition improves. Often the regression of pelvic findings is very slow, and it has been

noted that symptomatic improvement may take place with very little change in the pelvic findings. When the induration is hard and extensive, complete resolution may not take place for months or even years. Severe cases of pelvic cellulitis, usually associated with thrombophlebitis or septicemia, may prove intractable to therapy and end fatally. With a definite diagnosis of septic thrombophlebitis, ligation of the pelvic veins is sometimes indicated.

#### CONCLUSION

This article on salpingitis and pelvic cellulitis appears in a Symposium on Emergency Surgery. It is the consensus of opinion of leading gynecologists that the above conditions, when acute, are essentially non-surgical.

Certain complications of acute pelvic disease may require surgical intervention: pelvic abscesses, definite evidence of intestinal obstruction, or the rare complication of an intercurrent suppurative appendicitis. These complications are, however, the exception. Chronic pelvic inflammation may call for operation for relief from pain; by reason of adhesions, for menstrual disturbances, reinfection, and sterility.

When surgery is resorted to in pelvic parametritis it should be postponed until there is a definite abscess formation, as the infecting agent in these cases is usually the streptococcus which may retain its virulence indefinitely. The longer the delay, the safer the operation.

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To this day there are practising in India itinerant cutters for stone . . . The operator puts his finger in the patient's anus and hooks down the stone, which can be felt in the bladder, so that it presses hard against the perineal tissues. With an ordinary razor an incision is made over the flinty protrusion and deepened until the bladder is opened. The stone is extracted with a scoop and that is all.

# ABSCESS OF THE PROSTATE AND SEMINAL VESICLE

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## INTRODUCTION

**A**BSCESSES of the prostate and seminal vesicles are more often encountered in hospital practice among the very poor than in private practice because they are usually due to neglect of an infection. They may, however, occur in any patient. These two conditions do not necessarily occur simultaneously, and, in fact, rarely do, although each may develop separately from the same infection. They will, therefore, be considered in separate chapters.

## PROSTATIC ABSCESS

*Etiology.* Abscess of the prostate results from a breaking down of the tissues whenever multiple small abscesses, formed in cases of fulminating prostatitis, fail to subside.

A frequent cause of prostatic abscess is the gonococcus, but our own studies have shown that many other organisms may be present in abscess cavities in the prostate: *Staphylococcus aureus*, *Staphylococcus albus*, *Streptococcus viridans*, *Staphylococcus pyogenes hemolyticus*, *Micrococcus tetragenus*, *Bacillus proteus*, *B. pyocyaneus*, *B. coli communis*, and *B. typhosus*.

It is a strange but true fact that a prostatic abscess caused by the gonococcus frequently fails to show the organisms in the pus from the abscess cavity even though they may exist in profusion in the urethral discharge. In such cases the abscess fails to grow any organism. Eight of our forty-six cases were sterile.

Prostatic abscess may and often does result from too strenuous urethral instrumentation. Cases may also occur as a complication of influenza, typhoid fever, septicemia, diabetes mellitus, carbuncles, boils, or felons. In the three last mentioned

conditions the causative organism is the *Staphylococcus aureus*.

In a careful study by Hawes and Yunk of fifty-nine cases of prostatic abscess occurring on our service, twenty patients denied ever having had gonorrhea and ten had had the disease many years previous to the development of the abscess. These patients varied in age from 17 to 80 years. Thirteen were not operated upon, and forty-six were. Of the patients operated upon, thirty-two were between the ages of 20 and 40 years, one was in the second decade, seven in the fifth, three in the sixth, one in the seventh, and two were over 70 years of age.

*Pathology.* Abscess is a sequel of acute prostatitis. It is the fourth stage of an inflammatory process. A preliminary acute catarrhal inflammation is followed by follicular prostatitis, which is marked by the presence of multiple minute abscesses and dilatation of the prostatic tubules with pus, because during the inflammatory stage they fail to drain. The third stage is called parenchymatous prostatitis, and is an intensification of the second stage. The small abscesses become more marked, and the prostate is enlarged, tender, and hot. The inflammatory process either resolves under treatment or extends, with a resulting confluence of the small abscesses to form a large, fluctuating mass which may involve a large part of the gland.

Occasionally the accompanying periprostatitis forms an additional abscess, which extends rapidly and may even surround the rectum. Rarely a prostatic abscess may adhere to the rectum and rupture through, discharging its contents into that viscus.

*Symptomatology.* The usual symptoms of prostatic abscess are pain in the peri-

neum, difficulty in passing urine, chills, and fever. The leucocyte count is usually high, in our series varying from normal to

*Diagnosis.* A history of pyogenic infection, even in a distant part of the body, together with urinary disturbance is sug-

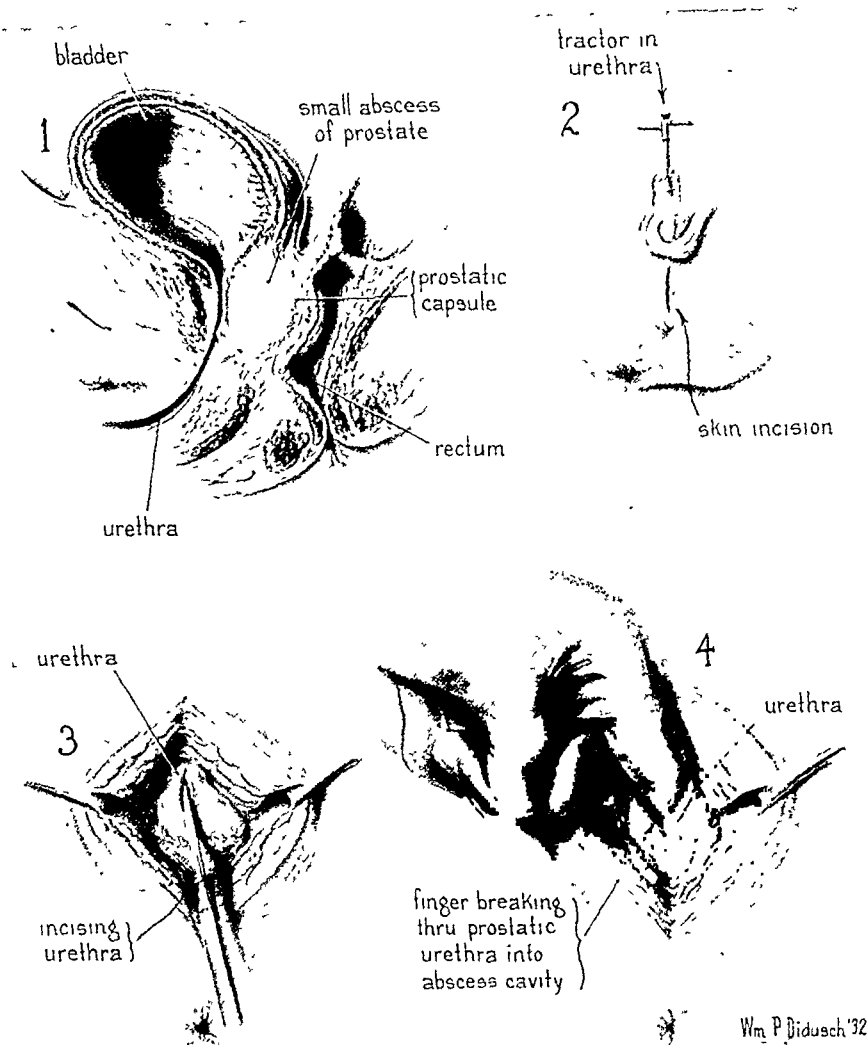


FIG. 1. 1, sagittal section showing a small abscess of the prostate gland. 2, Lowsley tractor in place. 3, incision through the external sphincter of the urethra. 4, finger introduced into prostatic urethra.

as high as 30,000. A cause of wonder to urologists is that there are occasional cases of huge prostatic abscess in which the only symptom is difficulty of urination. Eighteen of our patients had complete retention of urine.

There may be neither pain, fever, nor a high leucocyte count. The explanation of this lies in the type and lack of toxicity of the infecting organism.

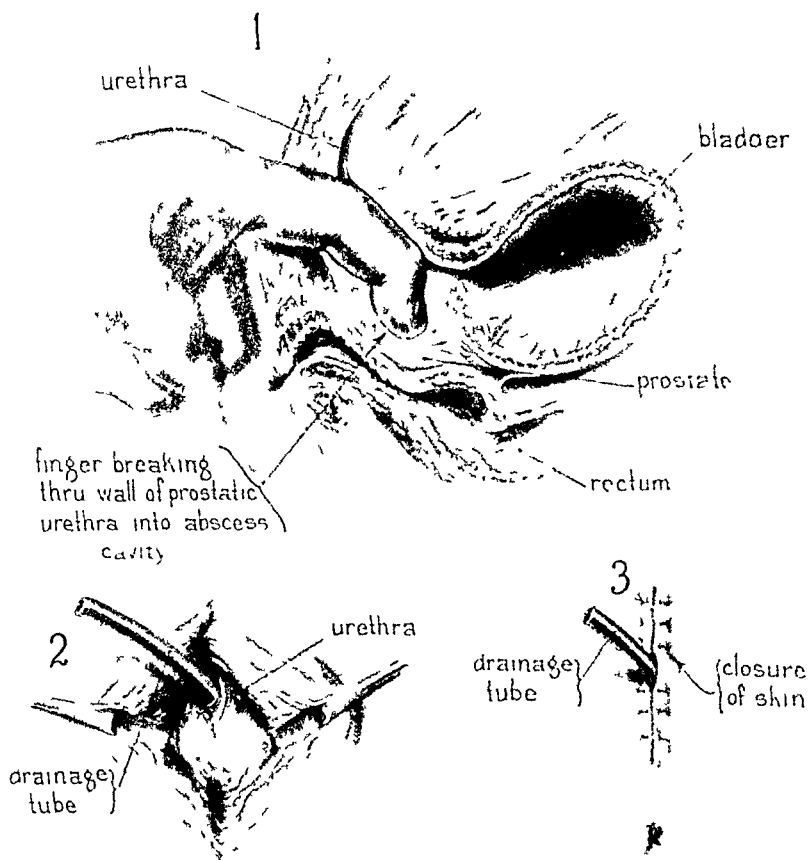
Chronic abscess of the prostate may develop insidiously and persist for weeks without causing any distress whatever.

gestive of the presence of a prostatic abscess.

The diagnosis usually is not difficult. It is based on two types of examination. First and most important is rectal examination. The palpating finger will detect an enlargement of the prostate gland; this is tender, hot, and often asymmetrical. The presence of fluctuation leaves no doubt about the diagnosis. If no fluctuation is detected, a needle may be inserted into the suspected portion of the gland and pus withdrawn, if present.

If no fluctuation or pus is noted, a cystourethrogram may be helpful in arriving at a correct diagnosis. The urethro-

If proper drainage is instituted the convalescence is usually satisfactory, although every prostatic abscess must be followed



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FIG. 2. 1, sagittal section showing the finger introduced into the prostatic urethra and into the prostatic cavity, breaking down the honeycomb arrangement of the abscess cavity. 2, showing a drainage tube in the urethra. 3, closure of the skin.

gram will show a large spread of the prostatic portion of the urethra, and the shadow of the abscessed portion of the gland projecting into the bladder, as shown in the cystogram, will be suggestive.

**Prognosis.** The prognosis is very poor if the abscess is untreated. The abscess may rupture into the urethra or rectum, or it may burrow into the perineum, bladder, or even into the peritoneum. In such cases the mortality is high, and, if death does not ensue, the convalescence is prolonged and complications serious.

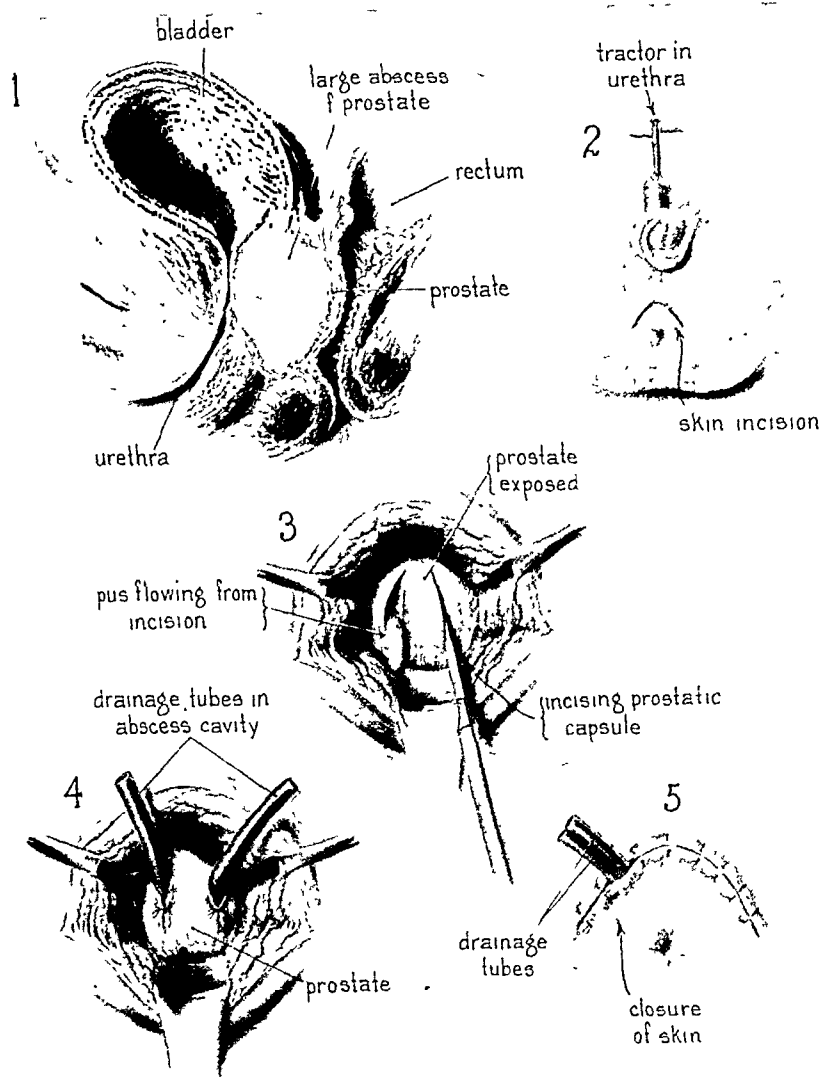
by a long course of treatment to ensure a normal gland.

Operation upon a prostatic abscess may be followed by impotence, due to the unbalance of the perineal musculature by the necessary dissection to expose the prostate. Such cases are all curable by the Lowsley plastic operation for the cure of impotence.

Thirteen of the patients in our series escaped operation and were cured by palliative means. Three of the forty-six patients operated upon died. One had multiple abscesses following an infection of his finger. The prostatic abscess was a part

of the general infection. *Staphylococcus aureus* was obtained from the blood stream. The second death occurred in a diabetic who had a *Staphylococcus aureus*

*Treatment.* The treatment of prostatic abscess consists of (1) medication by mouth; (2) diet; (3) local measures; and (4) surgery.



Wm. P. Didusch 1932

FIG. 3. 1, a large abscess of the prostate. 2, tractor in place, an inverted v incision having been made in the perineum. 3, the bulging prostate is incised, releasing pus from the incision. 4, two small soft drainage tubes are shown fixed in position in the prostatic abscess. 5, closure of the wound with both tubes coming through the same aperture.

infection of his prostate with abscess-formation. He expired on the eleventh postoperative day, having developed a *Staphylococcus aureus* blood stream infection. The third death occurred in a patient who had ulcerative colitis and developed a prostatic abscess which showed enterococci in the pus evacuated.

*Medication.* Urinary antiseptics should be given all patients suffering from infection of the prostate—not with the idea of curing the disease, but to prevent extension of the disease into the upper urinary tract.

The drugs most commonly used are methenamine combined with acid sodium phosphate or ammonium chloride, acriflavine, and, latterly, sulfanilamide in an

alkaline medium, avoiding any substance containing sulfates, such as magnesium sulfate, eggs, etc.

*Diet.* The diet should consist mainly of fluids until the acute stage is passed, and then a low protein diet, free from alcohol, red meats, tomatoes, berries of all sorts, carrots, and condiments, should be given.

*Local Palliative Measures.* Local palliative measures consist of the application of heat to the affected gland. This is best accomplished by the use of hot rectal douches several times daily. If this is impractical, hot sitz baths are helpful. Metal rectal tubes, through which a constant flow of hot water may be passed, are sometimes useful.

*Surgical Treatment.* A cardinal principle in the treatment of contained pus is to evacuate it. This may be accomplished in a number of ways. The method of choice is to do a perineal section, introduce the finger into the prostatic portion of the urethra and then into the abscessed portion of the gland, and clean out the honeycombed interior so that no pockets are left. A tube is then introduced into the bladder, diverting the urinary stream and leading the pus out through the perineal wound.

Another method of drainage is to expose the posterior surface of the prostate gland just as one does in doing the Young perineal prostatectomy, and then incise the abscess cavity and insert and fix a tube into it.

A third method of evacuating a prostatic abscess is to insert a large needle into the cavity through the perineum, with the finger in the rectum as a guide, and withdraw the pus through a needle with a syringe, as proposed by Barringer. This method is unsatisfactory, however, as drainage is not complete and the procedure usually has to be followed by open operation.

Still another method is the sound procedure suggested by Stevens. This consists in passing a sound into the prostatic portion of the urethra, where it is manipulated in such a manner that its end digs into the abscess cavity, evacuating it. Unfortu-

nately, this type of drainage is not complete, and the honeycombed interior of the abscess cavity makes for slow convalescence.

#### ABSCESS OF THE SEMINAL VESICLE

*Etiology.* Abscess of the seminal vesicle is an uncommon lesion. It may follow gonorrheal infection, tuberculosis (rare), or nonspecific infections from the colon bacillus, *Staphylococcus aureus*, etc. Prolonged congestion due to long-continued sexual excesses in the presence of infection (specific or nonspecific) may lead to abscess formation.

Infection may reach the seminal vesicles by extension from the prostatic urethra, either directly or by lymphatic invasion; or it may descend from above by extension from the genital tract; or it may be blood-borne.

*Pathology.* Seminal vesicular abscess follows acute vesiculitis. The vesicle may pass through three stages in the formation of an abscess. First there is an early catarrhal seminal vesiculitis. The vesicle is enlarged, soft, and drains freely on pressure. This is followed by an intermediate catarrhal condition in which the vesicle is still larger, piriform in shape, and drains poorly upon massage or ejaculation. The expelled fluid may be blood-stained and contains much pus. The third stage is abscess formation. The seminal vesicle is greatly enlarged, very hot, and tender. As a rule, no fluid is obtained upon massage. If fluid is obtained, it will be mucopurulent, often showing some red blood cells.

In later stages periseminal vesiculitis may occur. In such cases the vesicle is surrounded by an area of brawny edema which may simulate malignancy.

Abscess may occur in a seminal vesicle as an accompaniment of tuberculosis. When this happens, the bead-like appearance of the seminal vesicle usually seen in tuberculosis will be replaced, in part or all of the vesicle, by an abscess cavity.

*Symptomatology.* Acute seminal vesiculitis with abscess formation usually is accompanied by chills, fever, headache,

and other symptoms of general toxicity. Fever may, however, be absent. Frequency and dysuria are usual accompaniments. Pain is present and usually severe. It may be referred to the small of the back, suprapubic region, hips, or down the inside of the thighs. Cramp-like pains occasionally occur over the course of the ureter on the side corresponding to the affected vesicle, and may even extend into the kidney region. Pain following the sexual act is very common.

Objectively, there is extreme pain on digital examination. Enlargement of the vesicle is pronounced and fluctuation is frequently detectable. The heat in an abscess of a seminal vesicle can frequently be felt by the palpating finger. Pus and blood are observable in any fluid that may be expressed.

It is possible for a huge abscess to be present in a seminal vesicle in the complete absence of symptoms pointing to this region. In some cases there may even be no elevation of temperature and no change in the blood count.

**Diagnosis.** A history of preëxisting infection is suggestive. Digital examination of the region is helpful, and seminal vesiculography gives actual proof of an abscess if one is present.

If there is no history of infection and no symptoms pointing to the genitourinary tract, a history of arthritis should lead one to suspect the seminal vesicles if the teeth, tonsils, and sinuses are negative.

A rectal examination reveals the size of the seminal vesicle, as well as the condition of the prostate. A vesicle that is large, hot, tender, and fluctuating leaves no doubt as to the diagnosis. In some cases, however, the vesicle may be large, not tender, and surrounded by such an area of edema that there is doubt regarding the presence of an abscess.

The seminal vesicular secretion is usually easy to obtain. If a sterile endoscopic tube is passed into the prostatic urethra before massage, the secretions may be obtained under sterile precautions without con-

tamination of the flora of the anterior urethra. Lowsley and Delzell, using this method, found the gonococcus, Staphy-

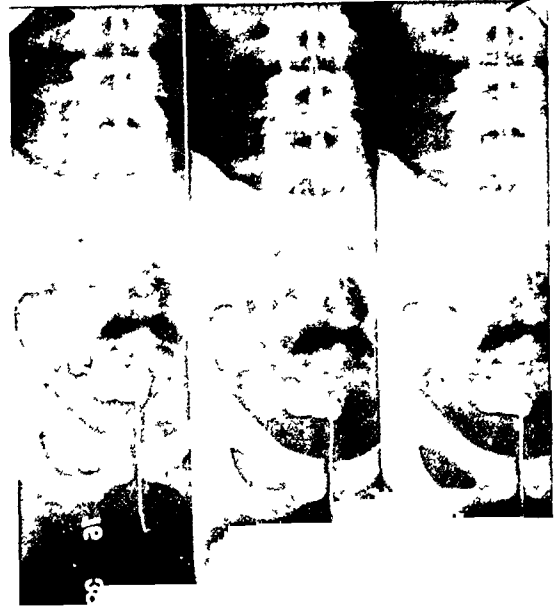


FIG. 4. An abscess of the right seminal vesicle injected through a catheter passed into the ejaculatory duct; the ampulla of the vas and the vas itself are also outlined.

lococcus aureus, Staphylococcus albus, Staphylococcus viridans, Staphylococcus hemolyticus, Streptococcus viridans, Streptococcus hemolyticus, Bacillus coli communis, Micrococcus tetragenus, Bacillus pyocyaneus, Bacillus proteus, and a diphtheroid bacillus. Thus it is seen that many organisms may penetrate the seminal vesicles.

**Vesiculography.** Advances in seminal vesiculography by Lowsley, Delzell, Peterson, and others have brought to the urologist a distinct aid for the diagnosing of abnormal conditions of the seminal vesicles. These have been made possible by the improvement in instruments.

Radiography, after the injection of neopax, sodium iodide, or other opaque media into the ejaculatory ducts by means of a small catheter through the Lowsley-Peterson urethroscope, gives excellent pictures of the seminal vesicles, permitting accurate diagnosis of an abscess if one is present.



*Prognosis.* Unless the abscess is fairly large, palliative measures may be successful in causing absorption. Large abscesses demand surgical drainage. Such cases, when properly drained through a perineal incision, usually do well. Following surgical intervention many patients have a temporary, or even a permanent, impotence. This is due to a disturbance of the perineal musculature, and can be cured by the Lowsley plastic operation, in which the bulbocavernosus and the two ischiocavernosus muscles are plicated with chromic ribbon gut.

*Treatment.* Treatment may be palliative or surgical. If the abscess is not too large, palliative measures of various kinds may suffice.

*Medication.* Sulfanilamide has been found useful in many cases. Forty grains daily, in divided doses, should be given for one week. While taking this drug the patient must take sodium bicarbonate and refrain from the use of epsom salts, eggs, and other substances containing sulfur compounds.

Methenamine and an acidifying agent are often useful when sulfanilamide fails or cannot be taken.

*Local Treatment.* Local therapy consists chiefly in the application of heat. This is accomplished by giving a hot rectal douche twice daily. The water should be at least 110°F. If this is not feasible, a hot sitz bath twice daily usually helps. The Elliott bag and the so-called rectal cooling tubes made of metal are other ways of applying heat to this region.

Often drainage may be aided by dilating the ejaculatory ducts with bougies through the urethroscope. Antiseptic solutions may be injected into the seminal vesicles and are in some instances helpful.

*Surgical Treatment.* Surgical treatment is accomplished by a perineal approach. After exposure, the seminal vesicles may be removed or incised and drained, depending upon the condition found by the surgeon. Under ordinary conditions excision is preferable.

Exposure of the seminal vesicles is accomplished as follows: The patient is placed on the table in an exaggerated lithotomy position. A Lowsley prostatic tractor is passed into the bladder, opened, and the prostate and seminal vesicles pulled up as far as possible.

An inverted v incision is made in the perineum. This is deepened into the rectal fossa on each side. The central tendon is cut and the anterior tractor is placed behind the transverse perineal muscles, which are pulled upward.

The apex of the prostate is located, the rectourethralis muscle cut, and the levator ani muscle is dissected away from the posterior surface of the prostate and seminal vesicles, which is recognized by its glistening fascia of Denonvilliers.

The rectum is separated from the posterior surface of the seminal vesicles and held out of the way with a gauze-covered posterior retractor.

A transverse incision is made into the two-layered posterior portion of the reflection of the peritoneum which covers the vesicles. (Unless both layers of this envelop are incised the seminal vesicles are not to be seen.) The vesicles are then dissected free, and incised or excised, as desired. If excised, the proximal ends are tied off and carbolyzed, and the ampullae are incised. Small, soft-rubber drainage tubes are sewed in position.

The wound is closed by one stitch of plain catgut, drawing the two sides of the levator ani muscles together. The skin is closed with silk or dermal.

# ISCHIORECTAL ABSCESS

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**A**CUTE abscess in the anorectal region is usually due to infection by the common pyogenic organisms following irritation, traumatism, inflammation, or ulceration in the anal canal. It has its point of origin most often at the pectinate line in one of the anal crypts. In relation to the anus and rectum, abscess occurs in various anatomic locations, thus:

1. If the infection extends upwards in the rectal wall the abscess originates in the submucosa. This location is rare.
2. Usually the abscess is outside the gut wall in one of three positions:
  - (a) Above the pelvic diaphragm in the superior perirectal space.
  - (b) Subcutaneous around the anus.
  - (c) In the ischiorectal fossa.

Of the above locations the most frequent position of abscess in the anorectal region is in the ischiorectal fossa.

## CAUSE OF ISCHIORECTAL ABSCESS

Besides chemical irritation and traumatism caused by the passage of bowel contents to the lower part of the rectum and anus, ischiorectal abscess may follow injury by the passage of foreign bodies, such as seeds, fragments of bones, toothpicks, or pins. These foreign bodies may become lodged in the anal canal due to the abrupt narrowing of the bowel at this point and the direction upwards of the anal crypts. When infection gains a foothold in such an injured area it tends to spread along the lymphatics or through the gut wall at the point where the levator ani and longitudinal muscular coat of the bowel pass between the sphincters, and in this way may reach the ischiorectal fossa.

Many ischiorectal abscesses result from the spread of infection from a neglected

posterior anal fissure. They also may be caused by strangulated, gangrenous, infected hemorrhoids. Occasionally abscess may follow anorectal operations due to spread of infection into deeper tissues but most often postoperative infection gives rise to a subcutaneous type of abscess.

In addition to the above causes infection and ulceration may originate in the anal crypts and terminate in ischiorectal abscess. Tubercle bacillus, gonococcus, and Vincent's organisms may be considered as causes.

Also an infection of an abrasion of the skin or acute inflammation of perianal skin without abrasion or ulceration may through the lymphatics terminate in an ischiorectal abscess. Infection may occur by direct extension from retrorectal or superior pelvirectal spaces, or from urogenital organs.

## SPREAD

When an abscess originates in the ischiorectal fossa it spreads through the loose adipose tissue without causing any obvious swelling until considerable tension is present. As it continues to develop it is limited laterally by the obturator fascia which covers the obturator muscle, and above and behind by the levator fascia which covers the lower surface of the levator ani muscle. The levator ani practically surrounds the rectum posteriorly in such a way as to form a space at the back of the anorectal junction through which the ischiorectal fossa may communicate with the one on the other side.

As the tension in the abscess increases it tends to burrow in the line of least resistance: it may travel downward to open on the skin surface, or along the anal

portion of the levator fascia, which is directly attached to the muscular coats of the anal canal between the two sphinc-

ter muscles. A pelvirectal abscess may rupture into the ischiorectal fossa and in this way

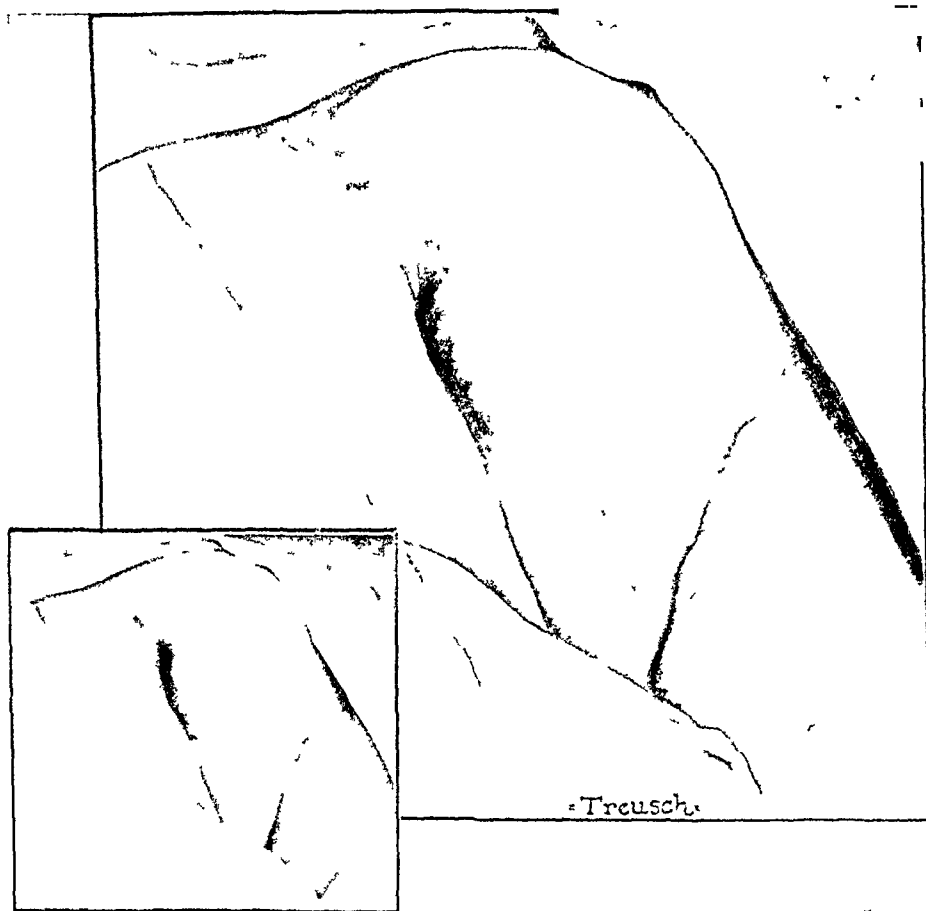


FIG. 1. Photograph and drawing of a large acute ischiorectal abscess.

ters, to open into the anal canal at the anorectal junction. However the infection may spread directly through the posterior passageway between the sphincters behind the rectum to the opposite side.

Infection in the anal canal, especially along the pectinate line posteriorly, may pass through the lymphatics to either fossa or to both, though the infection usually develops more rapidly on one side than the other. When both sides are involved it is known as a "dumbbell" abscess: such an abscess tends to terminate in a "horseshoe" fistula with the internal opening located at the posterior midline in the anal crypt. This indicates that the origin of the infection which terminates in an ischiorectal abscess was probably a

cause a pelvirecto-ischiorectal abscess. It is rare for an ischiorectal abscess to extend upwards into the pelvirectal space. In some cases it may extend between the sphincters upwards and form a submucous abscess.

The ischiorectal fossa is pyramidal in shape and is situated on each side of the anus and lower part of rectum external to the sphincter muscles. Under extreme tension it may distend to hold 4 to 8 ounces of pus. When more than this is evacuated one must suspect that an abscess in the superior pelvirectal space has perforated through the levator ani, forming a secondary ischiorectal abscess. The combined locations makes a condition very complicated and difficult to treat.

The possibility of tuberculous abscess in the ischiorectal fossa will not be discussed in this paper as it is rare: such abscesses

At first there are no apparent local signs but soon induration may be felt along the side of the anus, followed by increase of

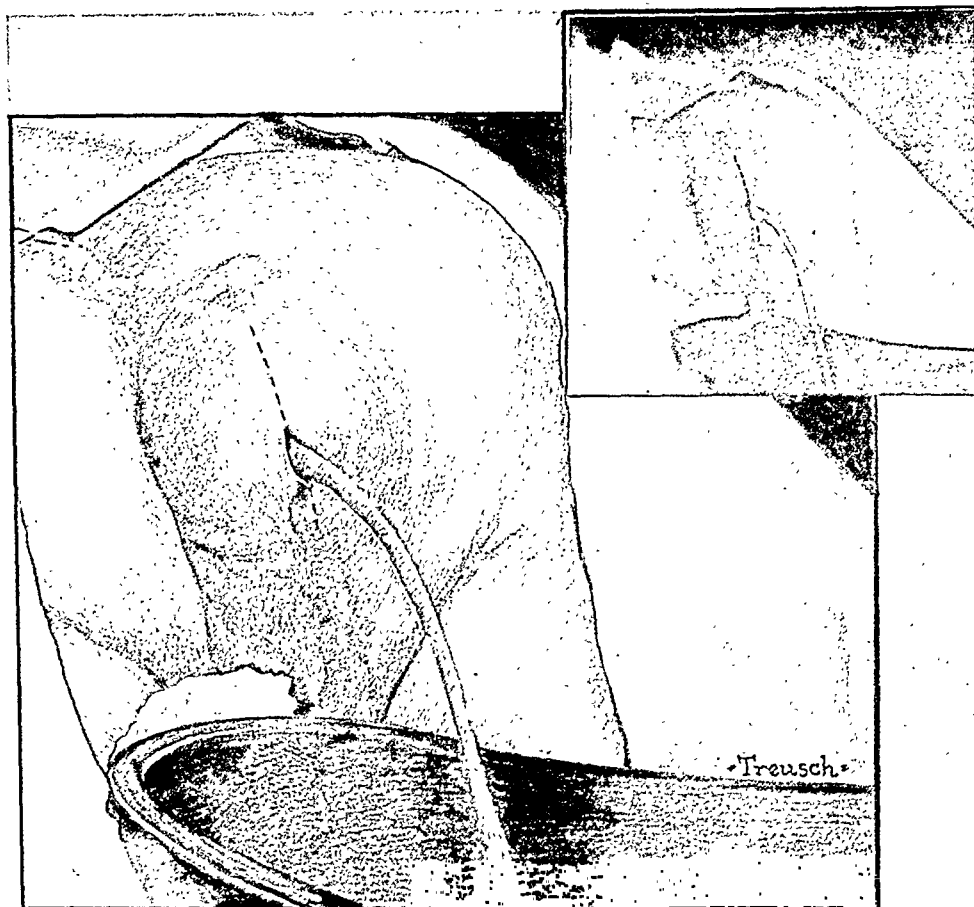


FIG. 2. A stab wound has been made in the ischiorectal abscess shown in Figure 1. The pressure within is illustrated by the force of the stream of pus spurting out of the abscess cavity through the stab wound photographed at the time of the incision. The dotted line indicates enlargement of the stab wound to permit evacuation of the pus and exploration of the extent of the cavity.

usually result as a secondary extension from above in the tuberculous patient.

#### SYMPTOMS

Ischiorectal abscess develops as an acute local inflammatory condition. The patient complains of chilly sensation, headache, fever, and at first local discomfort. As the abscess develops and tension increases the discomfort becomes a constant dull aching and a feeling of pressure which is not relieved by enema or defecation. Later this aching develops into an intense throbbing pain.

local temperature, redness and discoloration, the degree of which depends on the depth of the infection. When the abscess begins high in the ischiorectal fossa it may be necessary to introduce the finger in the anal canal and press outward to determine early induration and swelling. When the abscess has existed two, four, or more days a tense inflamed swelling which may or may not fluctuate is present at the side of the anus external to the sphincter muscles. If allowed to continue, it will open spontaneously as a rule on the skin surface or in the rectum at the anorectal junction.

## TREATMENT

From the etiologic factors involved one may appreciate the importance of preven-

the patient more comfortable. However, to temporize with such measures in hope that the abscess will subside is useless. To wait



FIG. 3 The dotted line in the photograph and the solid line in the drawing illustrate the racket-shaped incision employed to unroof the abscess cavity.

tive measures. These include avoidance of both constipation and of drastic purgatives, the avoidance of injury from enema tips, and care not to swallow seeds or other foreign bodies. It also is important to clear up local pathology.

When an ischiorectal abscess has developed, only one method of treatment should be considered: namely, opening and draining the abscess at once. As soon as the tension is relieved the abscess ceases to spread and an early incision may prevent subsequent fistula. Little if any result should be expected from the common use of rectal suppositories. If for some reason operation cannot be done immediately, hot fomentations and hot sitz baths tend to relieve pain and make

for the abscess to open spontaneously prolongs the patient's suffering and as the size of the abscess increases, it means healing will be prolonged and a fistula will almost certainly follow.

In cases where the induration and tumefaction are such as to bring up the question of gas gangrene infection, it seems wiser to administer sulfanilamide in large doses and wait. Often sulfanilamide gives relief of symptoms and causes the acute infection to subside. Then follows general improvement of the patient. Certainly this method of treatment is advisable until the question of gas gangrene is cleared up, as incision into such infection before pus formation is of doubtful value and may spread the infection.

*Anesthesia.* General and low spinal are the ideal methods of anesthesia.

Local infiltration of nupercaine (1:1,000) or procaine (1 per cent), etc. superficially over the area to be incised, are commonly used, but this anesthesia may be incomplete and at times limits the operation.

Never use ethyl chloride spray, as the anesthesia is incomplete, the extent of area limited, and the discomfort from the anesthetic agent is usually greater than the anesthetic effect.

*Operation.* The location and type of incision to be made depends on the extent of abscess at the time of opening. As a rule the incision should be made lateral to the external sphincter muscle into the most prominent area of swelling or induration. Incision into indurated area even before pus is formed may at times be advisable to relieve tension. It may prevent further spread of the abscess. The incision should be sufficient in length to give free drainage. To make a small stab incision into an abscess cavity and then plug it with gauze prevents drainage and can only cause pain to the patient. After drainage is established with a good free incision there is no advantage in irrigation or breaking up of the abscess cavity. Hot sitz baths not only make the patient more comfortable, but help to cleanse the parts and keep up drainage.

When the abscess is large and there is marked swelling of perianal tissue, an anteroposterior incision is made over the most prominent portion of the swelling across the entire width of abscess (Fig. 2); this incision should be made lateral to the sphincter. The finger is now gently introduced into the wound and the extent of the abscess cavity determined. Then with scissors or knife the roof of the cavity is cut away and the incision is continued into the anus, sparing the sphincter muscle,

leaving a racket-shaped opening. (Fig. 3.) This racket-shaped incision is made so that if a fistula should develop the external opening would be in the handle of the racket near the anal margin and not far out on the buttocks as in a T-shaped incision where the lateral incision extends outwards. The reasons for the incision are: to remove the skin wall over the abscess cavity; to decrease the depth of the cavity; to bring the last part of the abscess cavity to heal near the anal margin; and to place the handle of the racket as far back towards the posterior anal margin as possible. It may be necessary to cut away much of the cutaneous structures. Packing should be avoided other than for control of hemorrhage. The patient is put to bed and in about two days hot sitz baths are begun. It is hardly believable how rapidly the cavity of the abscess may be covered over with new skin. The cutaneous structures should be kept open until the abscess cavity can heal from the bottom. The patient should be told that a fistula may follow and a later operation for this may be necessary for a cure.

As a supportive postoperative treatment sulfanilamide in large doses often aids much in clearing up the infection, promoting rapid healing, and preventing a fistula. For some time this has been included in my postoperative routine.

To open an ischiorectal abscess in the acute stage and then proceed to do a radical operation for a fistula (cutting the sphincter muscles) may often leave a large open wound, marked retraction of sphincter muscle, followed by much scar tissue and deep sulcus in the anus and often partial or complete incontinence. Drainage of the abscess cavity as described above is all that should be undertaken in the acute case.



# THE EMERGENCY TREATMENT OF THROMBOTIC AND PROLAPSED HEMORRHOIDS

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SINCE not all thrombosed hemorrhoids are prolapsed, and only a small portion of the cases of prolapsed hemorrhoids are thrombosed, the emergency treatment of these conditions will be discussed separately.

## ACUTE THROMBOTIC HEMORRHOIDS

A thrombosed hemorrhoid may also be characterized as a "hemorrhagic pile," or a perianal hematoma.

Acute thrombotic hemorrhoids are caused by the rupture of some of the branches of the external hemorrhoidal veins. Internal hemorrhoids are infrequently thrombosed and as a rule only as a result of extraordinary trauma to those chronic internal hemorrhoids which usually have tended to prolapse. Both conditions are acute, and both conditions require emergency treatment.

Acute thrombotic external hemorrhoids occur much more frequently. They may occur as the result of trauma produced by constipated stools, fecal impactions, or foreign bodies. They may be produced also by traumatization during the careless insertion of examining instruments, or by foreign bodies inserted voluntarily by patients, or as a result of "hazing" by companions or fellow workmen. The trauma produced by the sudden descent of the diaphragm in sneezing, coughing, explosive laughter, the expulsion of large quantities of flatus, or following the expulsion of frequent irritating fluid stools, may also contribute to the production of acute external thrombotic hemorrhoids. Other causes are sudden jars, force, or local strain.

Sometimes one or two acute thrombotic hemorrhoids may be present without the

patient's knowledge until he feels them as rounded protrusions in the anal vicinity when cleansing himself following a bowel movement. At other times their appearance is accompanied by sudden severe lancinating pain.

External thrombotic hemorrhoids are easily differentiated from internal prolapsing hemorrhoids by the fact that they are covered with *skin*; while internal hemorrhoids are always covered with *mucous membrane*. Regardless of the amount of eversion, protrusion or prolapse, the covering of the hemorrhoid decides the type.

Patients, and sometimes even physicians, push acute thrombotic hemorrhoids, partially or completely up into the anal canal, or at least attempt to do so, and thus add pain and trauma to the suffering already present. External inspection of the parts should decide the diagnosis and indicate the proper treatment.

The acute pain which usually accompanies the appearance of acute external thrombotic hemorrhoids may be relieved temporarily by the use of hot compresses of a saturated solution of magnesium sulfate, glycerin, or 50 per cent witch hazel. Probably the best method of applying heat is to have the patient take a hot sitz-bath. A twenty minute immersion in water as hot as can be borne, will relieve pain and swelling in most every case.

Acetylsalicylic acid or other sedative remedies by mouth are also indicated, as are codeine, morphine, pantopon, dilaudid or other opiates hypodermically or orally. After several applications of the hot compresses or sitz-baths taken at two or three hour intervals, the pain and swelling may subside to such an extent that operative methods may not be necessary at the time.

However, in the majority of cases if the clots are not evacuated they tend to become infected and abscesses result; or

used to deaden the pain which accompanies the introduction of the needle. The needle is passed inward, upward and laterally in a

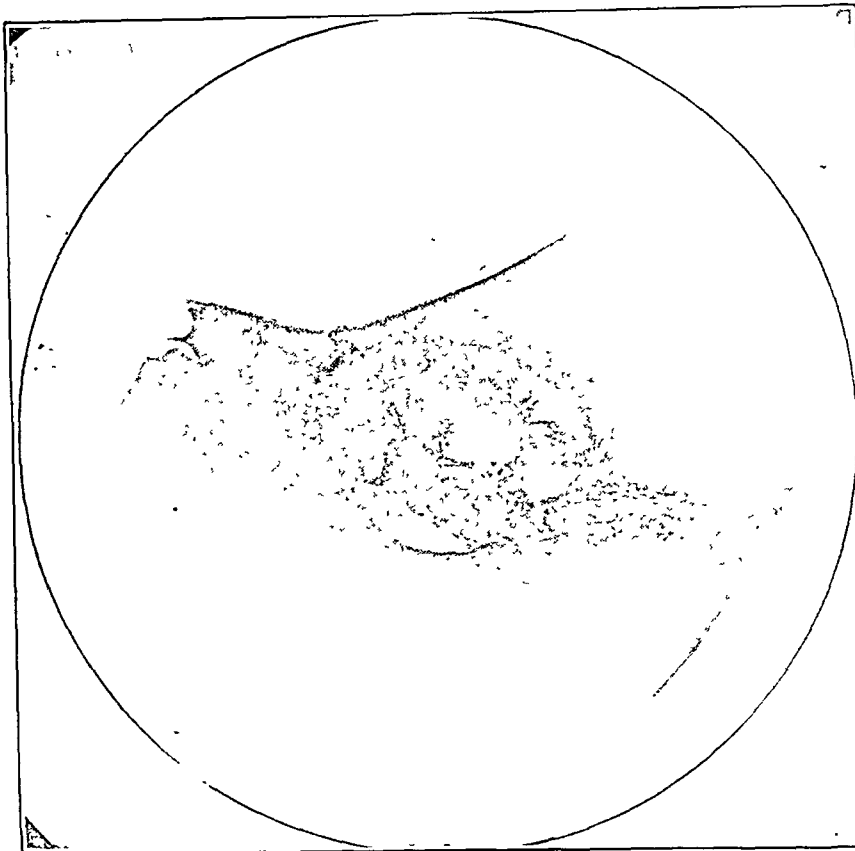


FIG. 1. Prolapsing internal and external hemorrhoids. Internal covered with mucous membrane; external with skin.\*

pressure necrosis will cause ulceration of the integument covering the growths. Sometimes this pressure is so great that a gangrenous condition will occur.

A simple technique for the removal of acute thrombotic hemorrhoids under local anesthesia is described:

*Operative Treatment under Local Anesthesia.* The patient is placed on the table in the left lateral or Sims' position. A 20 c.c. glass hypodermic syringe is filled with the solution of choice. Procaine (0.5 per cent) is used for anesthetizing the sphincter and is injected in the following manner: A point  $\frac{1}{2}$  inch below the posterior to the posterior commissure of the anus is selected. The application of a swab dipped in phenol is

V-shaped direction for about  $\frac{3}{4}$  inch, down into the sphincter muscle, but not through it. From 2 to 5 c.c. of the solution is slowly injected and the needle is retracted to the point of puncture, but not withdrawn; then it is pushed up on the other side in the same manner, keeping about  $\frac{1}{2}$  inch away from the anal aperture.

At least five minutes are allowed to give time for complete anesthesia. The sphincter will then be found sufficiently relaxed for any ordinary anorectal operation.

If but a single acute external thrombotic hemorrhoid is present, all that is necessary is to inject the hemorrhoid from its outer aspect with about 1 c.c. of a  $\frac{1}{2}$  per cent procaine solution. The injection is made subcutaneously, and not intradermally. The skin should be slightly raised up by the injected solution. The needle is then with-

\*The illustrations in this article are reproduced from Hirschman's "Synopsis of Ano-Rectal Diseases," published by Mosby.



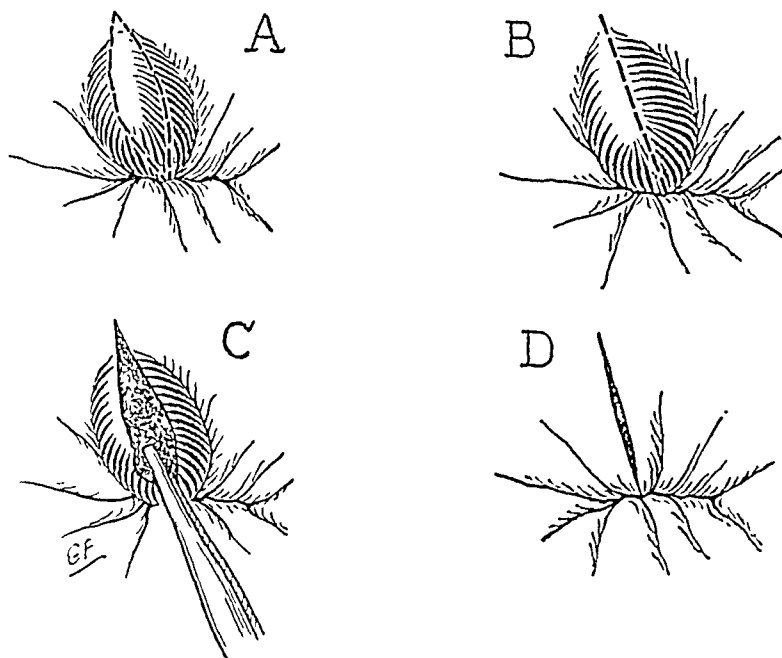


FIG. 2. Removal of acute external thrombotic hemorrhoid. A, elliptical incision. B, radial incision. C, removal of clots. D, edges of incision falling together after removal of clots.

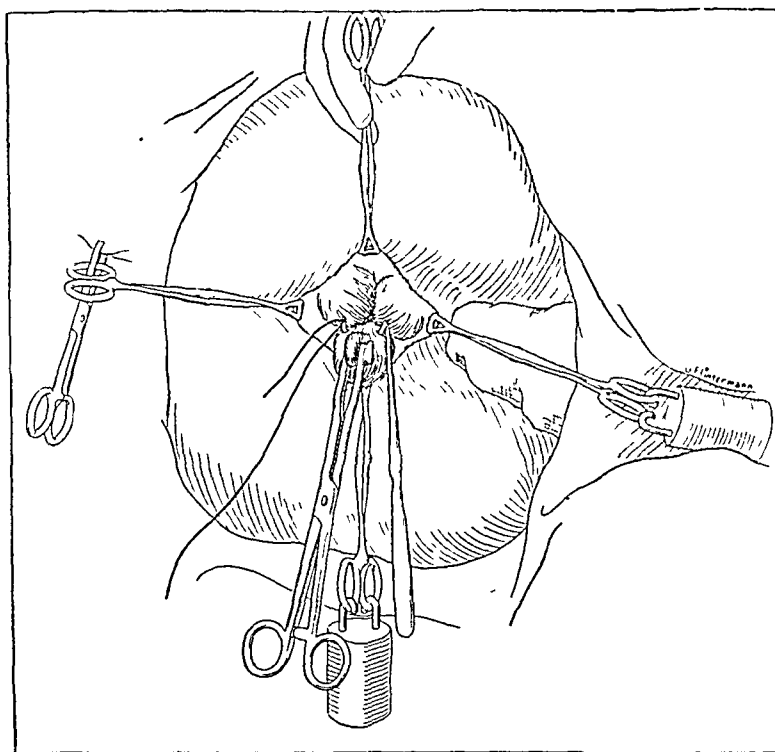


FIG. 3. The three usual hemorrhoidal groups with ligature being placed at the base of left lateral hemorrhoid.

drawn, and the same amount of the solution injected deep underneath the mass. After waiting about two minutes the pile is seen and dressed daily, and some mild antiseptic powder may be applied, such as thymol iodide, boric acid, or stearate of

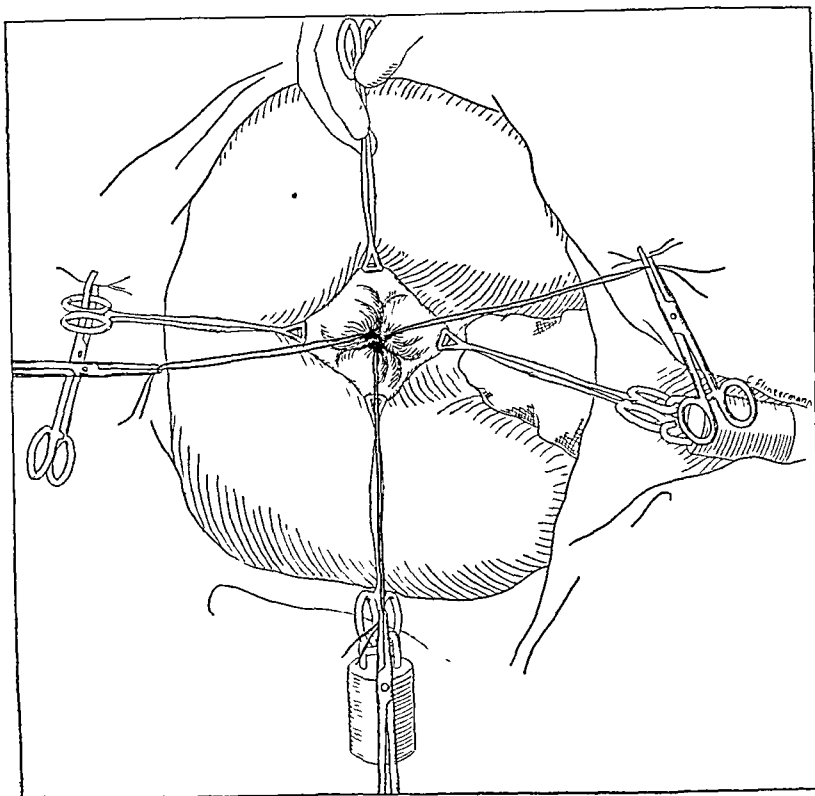


FIG. 4. The three groups ligated before removal.

removed through an incision made through the skin and down to the clot, radial to the anus and extending for about  $\frac{1}{4}$  inch into the skin beyond the tumor. The tissues around the tumor and below it are again injected if necessary when it is dissected out by means of a small-toothed forceps and curved scissors. After the clot is removed, the surgeon should look carefully into the wound for other smaller clots and remove all of them.

The edges of the wound are trimmed back in an elliptical manner to leave a gaping wound. This will heal by granulation from the bottom without any possibility of the edges of the wound turning in and retarding its healing. A  $\frac{1}{2}$  inch strip of rubber tissue may be lightly inserted into the wound, and a sterile dressing applied. This is removed in twenty-four hours, and it is not necessary as a general rule to use further drainage. The wound should be

zinc. The patient immediately after this operation, experiences a keen sense of relief from the removal of the tension caused by the thrombotic mass.

#### PROLAPSED INTERNAL HEMORRHOIDS

Patients suffering from prolapsing internal hemorrhoids almost all give a history of the usual hemorrhoidal symptoms. These are ordinarily bleeding, pain and protrusion. Hemorrhoids prolapse only after severe straining efforts, or following the passage of a constipated movement, unless they have been of long standing, and gradual inertia of the external sphincter has taken place. Patients suffering from this type of prolapse are often unaware of its occurrence. The pain is due not only to pressure of the thrombi on sensory nerves, but also by the spasmodic contraction of the sphincter muscles on the prolapsed

mass. Sphincter spasm and tenesmus are both extremely painful symptoms.

The prolapse which occurs with throm-

become thrombosed, is of course, the excision of the diseased tissue. This predicates a hemorrhoidectomy. Proctologists rarely

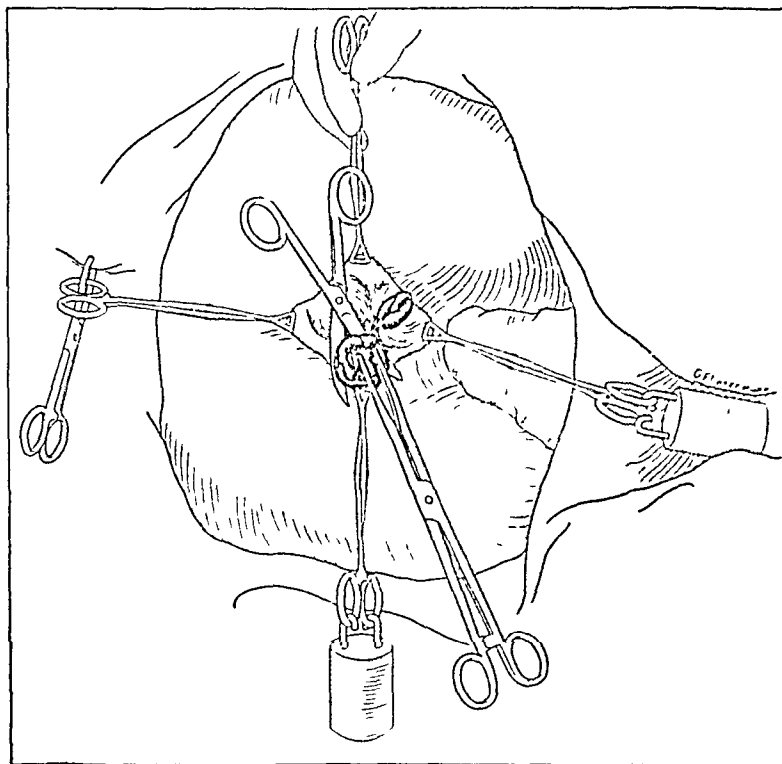


FIG. 5. Removal of internal hemorrhoid through left lateral incision.

bosis is accompanied by excruciating, almost unendurable pain, requiring hypodermics of opiates to give sufficient relief so that an examination can be made. The use of hot compresses or sitz-baths, as suggested for the treatment of acute thrombotic hemorrhoids may provide considerable relief. The diagnosis is usually self-evident.

Prolapsed internal hemorrhoids which become thrombosed appear as one or more rounded purple or dark tumors, continuous with, or surrounded by the anus. Usually the emergency treatment of any prolapsed condition starts with the reduction of the prolapsus. This is usually impossible without the employment of local, caudal or spinal anesthesia. In personal practice spinal anesthesia has never been found necessary for this procedure.

*Operative Treatment under Local or Caudal Anesthesia.* The emergency treatment of prolapsed internal hemorrhoids which have

employ general anesthesia for operations such as this. With the exception of a case where a thrombus has occurred in one or two hemorrhoids, there is no contraindication to—and usually every indication for—an internal and external hemorrhoidectomy.

Where a single hemorrhoid has been thrombotic—after anesthesia has been produced—an elliptical flap of the mucosa is excised and the clots either emerge or are expressed. If a small artery has been cut, the spurting vessel is ligated with No. 1 plain catgut. Venous bleeding is controlled by a touch with the cautery or a pressure bandage.

The author's technique for hemorrhoidectomy is as follows:

After the patient has been relieved of the acute pain by sedation, 3 gr. of phenobarbital are given and a one-quart hot soda bicarbonate enema is administered. One hour after this has been expelled or

siphoned off the patient is ready for surgery. After skin sterilization according to the technique preferred by the surgeon,

equidistant points. Two are placed on the lateral anal edges, one anterior, and one posterior. Since most internal thrombotic

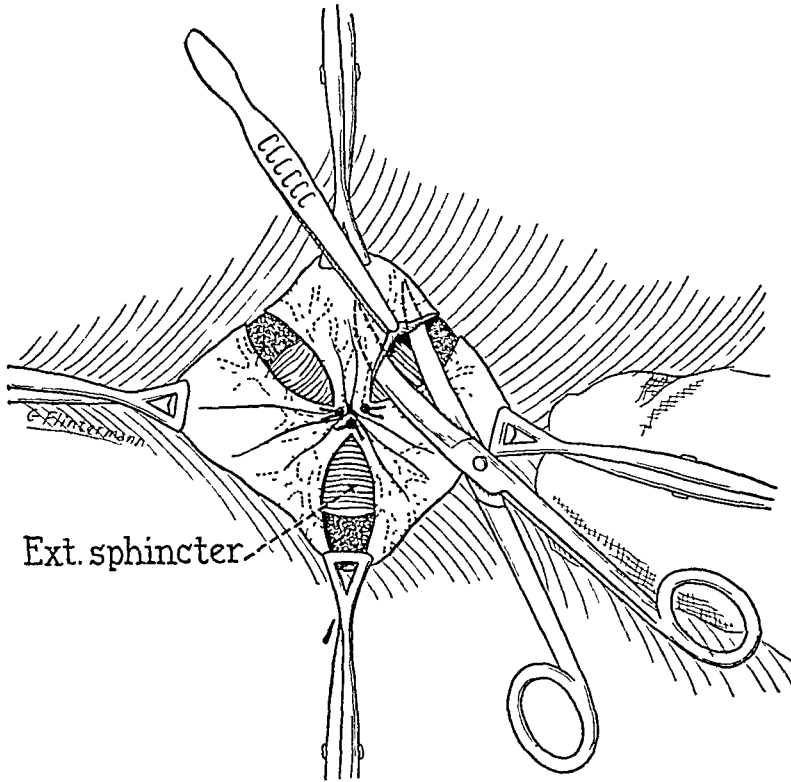


FIG. 6. Division of communicating veins between right anterior and right posterior incisions. Note three radial elliptical incisions exposing external sphincter muscle.

caudal anesthesia is administered. We give 40 c.c. of 2 per cent solution of procaine in Ringer's solution, injected through the caudal hiatus into the caudal canal. If piston pressure indicates that the canal is not filled, sterile water is added until there is considerable resistance to pressure. When the needle is inserted into the caudal canal, aspiration should be performed in order to be certain that the needle has not punctured a vein. If blood appears on aspiration, a vein has been punctured, and the needle should be withdrawn and reinserted. From seven to fifteen minutes is usually required for anesthesia to become complete.

Any form of hemorrhoidectomy which removes only enough mucosa to expose a thrombotic mass and yet allow of its complete removal along with any other varicose veins can be employed. Our technique is as follows: Triangular or Allis forceps grasp the perianal skin at four

hemorrhoids are accompanied by some external thrombosis as well, it may be necessary to place these forceps on the external thrombotic areas. As these are to be excised later, no concern should be felt about this. Traction on these four everting forceps will expose the entire operative field in a way not possible by the employment of specula or retractors. No part of the area is obscured by any part of a speculum or a retractor. The relation of each hemorrhoidal mass to the others can be accurately observed.

Inasmuch as most hemorrhoids occur in three constant areas, they can be removed in three groups, the right anterior, right posterior and left lateral. With the patient lying on the left side the most dependent group would be the left lateral, and this is therefore the first to be removed. The hemorrhoidal mass is grasped at its outer extremity with Hirschman pile forceps, or a

similar instrument, and a blunt-pointed ligature carrier or a small round curved needle, threaded with No. 1 chromic catgut is passed in through the mucous membrane on one side, down to the base of the hemorrhoid, and around to the opposite side in such a manner as to include the upper half of the mucous membrane covering the pile and surrounding all blood vessels underneath. This ligature should be placed just at or above the juncture of the hemorrhoid with normal mucous membrane. It is then firmly tied, thus securely shutting off the blood supply of the hemorrhoid.

The right anterior and the left lateral hemorrhoidal groups are treated in like manner. The ligatures are left long and are held out of place by hemostats. After all ligatures have been placed, the left lateral hemorrhoid is again grasped with the hemorrhoidal forceps and an elliptical flap excised sufficiently large to expose the clots and varicose veins composing the hemorrhoid. Some of these veins and clots may come away with the flap.

All others are carefully dissected out until the sphincter sheath is exposed. Should there be any arterial spurting, usually from the mucosal walls, the hemorrhage is controlled by No. 1 catgut ligatures. As a rule there is no such hemorrhage because of the control of hemorrhage produced by the original three ligatures. The right anterior and right posterior hemorrhoids are excised in the same manner. Care should be used not to excise any more of the normal mucosa membrane overlying the hemorrhoidal mass than is necessary to expose the pathology. When these operative wounds contract they appear to be but slits or "buttonholes." The cut edges are allowed to fall together without suture.

The hypertrophied external skin folds, whether they contain thromboses or not, are excised radial to the anal aperture. All veins between the incisions are undercut beneath the mucous membrane inside, and subcutaneously outside. All of these radial wounds are tapered, so that no cupping occurs. A tapered wound not only drains well but reunites better and prevents edema.

Ten c.c. of 1 per cent diothane solution is injected underneath the incisions and circumanally. This produces a degree of postoperative anesthesia which may last for several days, and is responsible for the comfort and shortened hospital stay of these patients after the usual external or internal hemorrhoidectomy.

A strip of rubber tissue with some analgesic ointment is inserted into the canal and a compression dressing applied. The patient is put on a minimum residue or fluid diet and is allowed to leave his bed within twenty-four hours if necessary.

The usual period of hospitalization runs from three to seven days.

#### CONCLUSIONS

This technique is simple and effective for the following reasons:

1. It can be performed without general anesthesia.
2. Hemorrhage is controlled before it can occur, by the preliminary ligation.
3. A minimum amount of mucous membrane is removed and the pathology is removed largely by submucous excision.
4. No packing, plugs or tubes are required.
5. There is no diminution of the bowel caliber.
6. The period of hospitalization is minimized.



# FRACTURES AND FRACTURE-DISLOCATIONS OF THE SPINE

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THE recognition of fractures of the spine, especially of the milder types, is becoming more general. It also has become a matter of routine to suspect their presence with other types of injury in a fairly regular percentage of cases. This is particularly true of their association with fractures of the os calcis. So it is important to analyze carefully the history of injury. In many hospitals it is becoming routine not only to examine carefully for such a possibility, but to x-ray the spine thoroughly to rule out its presence. This is especially important in the group of cases where there is a history of a compression and impaction force, though often the symptoms may be only vaguely suggestive.

On the other hand, the changes which have taken place in transportation—the wide use of the automobile with its ever increasing speed, as well as the more hazardous types of industry—have increased the liability tremendously.

The force causing such fractures is either a quick hyperflexion force, such as results from passing over a dip in the road in an automobile, where the rider receives a jouncing action, or where a compression force is brought to bear on the spine, such as would result from a fall from a height, or from a blow on the head in a fall or in diving in shallow water. In cervical fractures, comminuted fractures, and in fracture-dislocations, twists and lateral force undoubtedly have a direct influence.

Fractures of the spine may be quite mild as to their outcome, as in the simple impacted group, whereas, on the other hand, they may be extremely serious, especially the cervical fractures in the level of the atlas and axis, or in the comminuted and dislocated cases commonly seen in the dorsolumbar level. It is because of the serious nature of these latter mentioned

groups that we should continually bend every effort to educate the layman, the foremen on jobs, and especially those whose duty it is to render first aid, such as highway patrol and ambulance men, in the careful handling of all injured people. Probably the most serious risk is in the handling of those injured in the highway automobile accident.

A few simple rules for the handling of accident cases may be stressed:

A. Always handle the injured without twisting or bending the body. In no instance allow a sitting or standing position until an examination has been made.

B. A rigid stretcher is to be used at all times.

C. All seriously injured or suspected patients should be taken immediately to a properly equipped hospital where the treatment is to be instituted, and not first to a police station and next to an emergency hospital, thus losing valuable time in unnecessary handling and examinations.

Upon the admission of the patient to a hospital, a thorough physical examination should be made to determine the general condition and the possibility of other fractures, such as those of the os calcis. The most important part of the examination is in determining the presence of cord or nerve root involvement, since the x-ray examination should be guided directly by the findings, and the technician warned accordingly of the risks in the handling of the patient. Very often the approximate level can be determined fairly accurately. It is of the utmost importance that when neurologic symptoms are found, a detailed neurologic examination should be done immediately, before the x-ray examination, and the findings recorded.

If it is judged proper, the patient may be carefully moved to the x-ray department

for that portion of the examination, but if in the first examination one is suspicious of cord or nerve root injury, the x-ray exami-

early a reduction as possible is indicated. The earlier done the more easily accomplished. If complications are going to

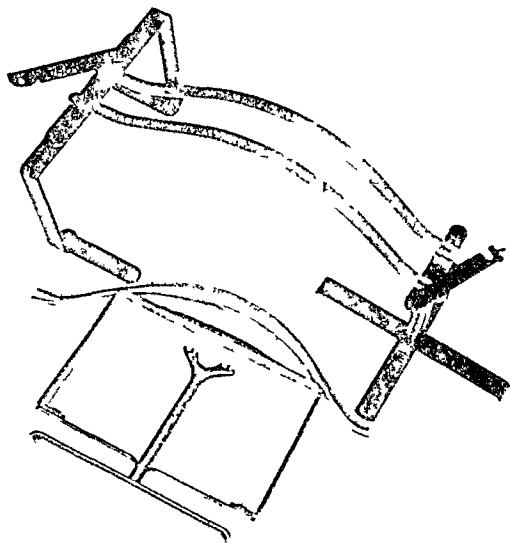


FIG. 1. Photograph of two portable Goldthwait frames, one assembled for use and one taken apart and ready for transportation. These frames may be set on any steady table, such as is found in every kitchen. It is quite as efficient as the hospital type of frame.

nation should be made in the bed, even if the bed has to be moved to the x-ray department. This is more true in cervical fractures, but is equally applicable to cases with symptoms of cord injury at a lower level.

Since fractures of the spine frequently occur at more than one level at the same time, the entire spine should be very thoroughly covered by the x-ray examination. Careful judgment should be used in the taking of the roentgenograms as to the amount of movement permissible, since not only may the pain be severe, but permanent damage may be done by changing the position of the fragments. The radiologic technicians should be minutely instructed in such technique.

After the fracture has been demonstrated by the roentgenogram—the general condition of the patient permitting—immediate arrangements should be made for the reduction and application of the fixation cast. As in all other types of fracture, as

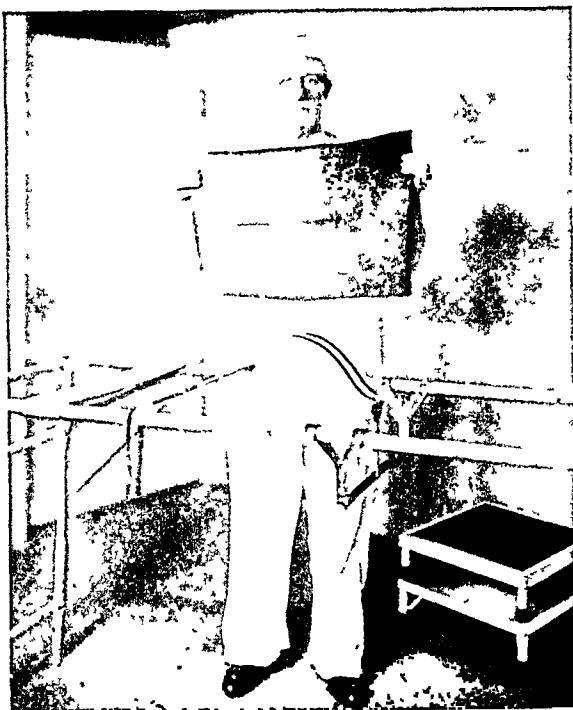


FIG. 2. Method of reduction. Hospital type of Goldthwait frame. This is attached to an ordinary gas-pipe frame. The two curved bars are the important elements. They are bent for each case, in order to bring the highest part of the curve just under the fractured spine, which has been compressed. The bars are made of spring steel, so tempered that they will remould the spine of a heavy man; it is essential that their flexibility be perfect. The felt pad is placed on the bars, to be included in the cast. The latter is applied as the patient lies on the bars after the successful reduction. The split in the felt pad is to relieve the pressure on the spinous processes.

A portable Goldthwait frame is quite satisfactory. The bars are interchangeable with those of the hospital type.

arise, it is much better that the reduction be accomplished first. For instance, in a certain percentage of cases, temporary paralytic ileus develops, and it is just as likely to appear before as after reduction. In a recent case, reduction was delayed because of its presence, and as the condition did not improve over a period of several days, the reduction was done and immediately the condition disappeared. It may be that the condition had about reached its end, or it may be that the

accomplishment of the reduction had something to do with its cessation.

Also, other complications may arise, such

well be removed, but if paralysis comes on slowly it is fairly certain that it is due to cord pressure. Such pressure may be from

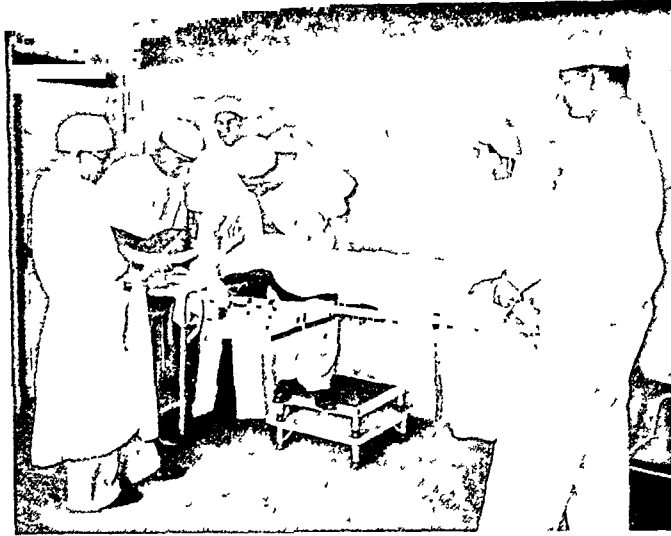


FIG. 3. One of the methods of producing hyperextension. The patient is placed on the Goldthwait frame. He is balanced by one assistant who holds the legs, and by two others who balance the shoulders by means of a folded sheet passing to the opposite axilla. A folded sheet is passed under the body at the level of the fracture and is tied over the shoulders of the operator, who then lifts the spine into the amount of hyperextension necessary to pull out the impaction of the vertebrae. When this is accomplished, the patient is lowered to the bars of the frame and an x-ray film is made to note the success of the maneuver and of the moulding of the spine on the frame. If the result is satisfactory, the plaster cast is then applied without further moving the patient.

as acute colds and pneumonia, which postpone the reduction indefinitely, or even interfere with its accomplishment. Early reductions are definitely more accurate than those done after a delay, and the perfection of reduction is in direct ratio to the time elapsed after the fracture has been received.

When all the data have been obtained by the physical examination—necessary laboratory examination including the Queckenstedt test, and the roengenologic examination—a proper analysis will determine the possibilities of manipulative or operative correction procedures. The only immediate operative procedure to be considered is a laminectomy. In those cases with a complete cord severance, resulting in immediate paralysis, laminectomy is not indicated. If cord pressure is proved to be the result of splinters of bone, they might

slight misplacements or narrowing of the canal due to the mechanical kyphos, causing localization of hemorrhage or edema. In all cases where a misplacement could in any way account for the pressure symptoms, the injured should be given the benefit of a manipulative reduction. It is surprising how frequently such symptoms will clear up following a successful manipulative reduction and proper fixation.

In all cases with neurologic symptoms, special precaution must be taken with every stage of the manipulative procedure. A reduction should never be undertaken until the surgeon is satisfied as to the cause of the paralysis, and then manipulation and fixation are planned to suit the individual case.

It is highly important that every hospital accepting emergency work should be properly equipped to handle spinal injuries.



A detailed list follows of all the necessary material and equipment, which in analysis are quite simple:

9. A hospital cart for transportation of patient to and from the operating room.
10. A Goldthwait frame, with a choice

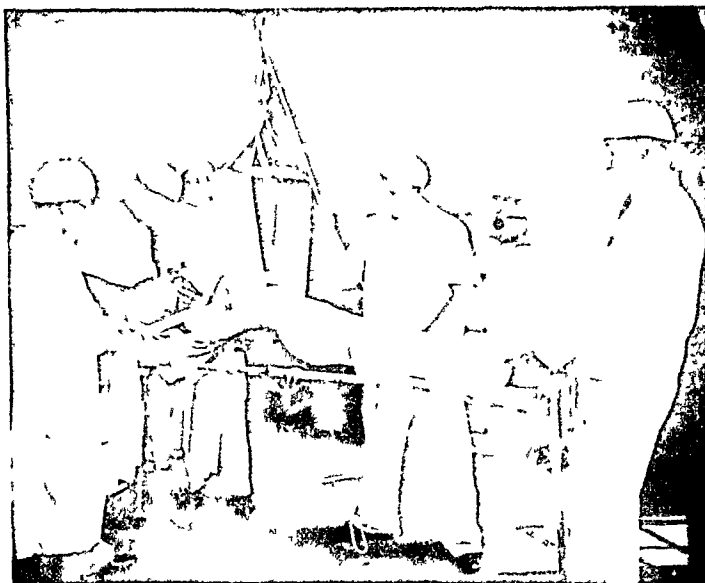


FIG. 4. Another method of producing hyperextension, devised by Dr. John Wright of Pasadena, California. It is easier on the operator in controlling the amount of hyperextension. In other respects it is exactly the same as the method indicated in Figure 3.

1. Stockinet of sizes to fit both slight and stout individuals. Several different widths should be available.

2. Unbleached cotton bandages sufficiently strong to be placed under the stockinet to be used as leaders for pads, for the application of alcohol and powder to the body within the cast.

3. Heavy gray felt, 1 inch thick and not too tightly compressed.

4. Sheet wadding, rolled in widths of about 6 and 8 inches.

5. Plaster bandages, 6 and 8 inch widths.

6. Plaster reinforcements sufficiently long to extend from top to bottom of cast, approximately 20 inches in length, and about 6 inches in width. Each jacket requires about six such reinforcements.

7. Two deep buckets for wetting plasters (plaster bandages to be put in end on for thorough wetting).

8. Knives for trimming cast after application.

of bars of proper length for the individual case, and of the correct temper for the weight of the patient.

11. A fracture table with shoulder supports, for use in cervical fractures as described later.

12. A hook in the ceiling securely fixed to hold several hundred pounds weight.

13. A hook in the wall at level of height of fracture table, to be used in the correction of cervical fractures.

14. A block and tackle.

15. A strong webbing belt and spreader, so arranged that it can be easily attached to hook in block and tackle.

For the *cervical* cases, the following in addition:

16. A thin, narrow board, to support the body and neck up to the head.

17. A Glisson sling and metal spreader.

18. A spring balance.

19. A portable x-ray machine, to be used in the plaster room in all spinal fracture cases.

20. A sufficient number of assistants or nurses to do the job. We find five, in addition to the anesthetizer and surgeon, to be the proper number.

If the diagnosis indicates that reduction is advisable, any fracture of the spine can be properly and accurately reduced with the equipment listed above, and should be accomplished in approximately one hour, counting in the time involved in having one or two sets of check-up roentgenograms made. It has been accomplished within a half hour.

The following detailed description of the procedure is that followed in the most simple type of compressed and impacted fractures, the more complicated cases requiring variations which will be described under their special headings.

#### PROCEDURE FOR THE ORDINARY DORSOLUMBAR COMPRESSED AND IMPACTED FRACTURE

The patient is anesthetized on the surgical cart. We prefer a preliminary avertin followed by a gas anesthesia. The patient, still on the cart, is placed directly under the hook in the ceiling, to which is attached the block and tackle. The webbing belt is then passed under the affected area and strapped over the spreader, and the spreader is attached to the block and tackle.

An assistant now balances the legs, and each arm is balanced by a separate assistant, as the operator lifts the patient on the sling into a hyperextended position, with the fulcrum at the level of fracture. Depending upon whether there has been a simple compression or a deep impaction, the operator will be guided as to how much force is required to disimpact the fragments. During this maneuver the alignment of the patient is scrupulously maintained. When the disimpaction has been accomplished, the cart is removed while the patient is held up by the sling and balanced by the assistants holding the arms and legs. The Goldthwait frame is now placed under

the patient by other assistants, so that when he is let down upon it the high point of the bars of the frame will be exactly at the level of the fracture. The height of the bars has been previously adjusted by the operating surgeon so that when the body rests upon them the spine will so mould itself as to bring the loosened fragments into proper alignment. It is this moulding power of the bars of the Goldthwait frame that is responsible for such perfect reductions.

Next, the large felt pad upon which the patient rests is placed on the top of the bars. This must be 1 inch thick, and as long and as wide as the body of the patient.

A lateral roentgenogram is then made to demonstrate the correction of the alignment, and if it has not been wholly successful the manipulation by hyperextension with the sling and block and tackle is repeated. Rarely has it been necessary to repeat this disimpaction maneuver more than once.

In those cases where there has been compression without impaction or extensive comminution, little or no hyperextension may be necessary, the Goldthwait bars readily accomplishing the reduction with the patient fully relaxed.

When one is satisfied that the reduction is completed, the body is wrapped with a thin layer of sheet wadding, the bony prominences padded with felt a half inch in thickness, and the supporting cast then applied.

The cast should be made so that there is a rigid three point control—the high point of the spine at site of fracture in the back, and at the very top and bottom of the cast in front—and it should fit as snugly as possible about the pelvis.

When the cast is thoroughly set, the patient is removed from the frame by means of the sling and block and tackle, and placed on his side on the transportation cart, the bars of the frame remaining in the cast. The bars are now slid out of the cast, and the cast trimmed about the pelvis and arms for comfort, and to allow care for

nursing purposes. In addition, a window is cut to expose the epigastric area of the abdomen. This was originally done to facilitate abdominal examinations in those cases developing ileus, but it was found most comfortable in the presence of abdominal distention due to gas. It also helps in the after care of the skin within the cast.

The patient is then placed in bed and a pillow is kept under the high level of the lordosis until the cast is dry, to prevent sagging and loss of position of the fragments.

From this time on and during the remainder of the period in bed, there are only a few rules important to observe.

1. Never turn the patient on his face. He may be turned to 80 degrees from the flat of the back for one hour each day on each side, to rest the spine.

2. Each day the entire body within the cast must be given an alcohol rub and powdered. This is accomplished by passing pads tied or sewed to the bandages, leaders having been placed within the stockinet for that purpose, and using a see-saw movement. Great care must be used to pass the pads across the area of fracture where the cast fits most snugly, otherwise a pressure sore may develop at this point. If this appears imminent it is advisable to cut a narrow window, just large enough to release the pressure on the tips of the spinous processes, but still not remove the control from the lateral processes. A window  $1\frac{1}{2}$  inches wide, and from 4 to 5 inches long has always been sufficient, and in a long series of cases it has not been found necessary in more than a dozen cases.

The patient is kept flat in bed for fourteen to sixteen weeks, or until a roentgenogram shows that the bone repair is sufficiently firm to hold the correction with the superincumbent weight of the body when standing or sitting.

In no other method, where standing has been permitted, has there been such a high percentage of retention of full corrections. If the correction is not maintained, why do a correction?

Check-up roentgenograms are made as soon as the cast is dry. After fourteen weeks, the cast is split on both sides, the patient rolled out, measurements made for a Taylor back brace, and a roentgenogram made. The patient is then returned to the split cast until the back brace is finished.

With the brace on, the patient is stood up, always with heavy shoes to support the feet, and from *that* time on a gradually increasing amount of weight bearing and walking is encouraged until full strength is recovered. These patients gradually increase the distance to about a five mile walk daily, and often pool swimming in addition, together with special pool exercises. They are encouraged to return to duty after approximately seven months from time of accident, and if the reduction has been accurate and well maintained this should be possible without any disability. If disability remains, it is unquestionably due to ligamentous, nerve root, or slight cord injuries, which have been unrecognizable, and they are of low incidence.

In the badly comminuted fractures, a longer time is required to obtain firm bone repair.

**Warning:** Care must be taken in all fractured spines before manipulative reduction is undertaken, to rule out fractures of the arch, for if present, an entirely different procedure is advised.

This method is recommended because of its simplicity and its accuracy and retention of reduction. The point which speaks loudest for its success is that in the thirteen years it has been used there has been but one change in the procedure, i.e., a variation in the amount of force that may be necessary to produce disimpaction.

It is now recognized that the amount of force necessary may be judged by the appearance of the roentgenogram. In deep impaction much force in hyperextension may be necessary to sufficiently loosen the fragments. However, in the great majority, as little force as was used in the first case done is found to be sufficient, and where impaction is absent, little if any forcible

hyperextension is necessary preliminary to placing patient on the Goldthwait bars for the moulding of the spine.

#### COMMUNUTED FRACTURE DISLOCATIONS

This same technique is followed in fracture dislocations or comminuted fractures of the spine, *with very definite restrictions*. The sling is not used for hyperextension or for lifting the patient. The amount of movement of the spine accomplished in this way is absolutely contraindicated.

The patient is placed very carefully and with as little movement as possible on the previously prepared and padded Goldthwait frame.

Traction and countertraction with the body firmly supported on the bars of the frame is the important feature of the reduction. This is accomplished by traction on the legs against countertraction obtained by two assistants with folded sheets placed under the opposite axilla from which they pull. In this way too great pressure is not placed on the axillary vessels and nerves. This traction should be steady and prolonged, with possibly extra hyperextension to mobilize the fragments slightly, accomplished by lifting the fractured area of the spine with one's arms, or possibly a folded sheet under the level of the fracture.

After what is judged to be sufficient moulding has taken place, lateral and anteroposterior roentgenograms are taken to see what has been accomplished. With complete relaxation under anesthesia it is surprising how much reduction may be obtained. If in the surgeon's opinion, still more correction can be accomplished, further traction may be applied.

A plaster jacket is then applied just as the patient lies on the frame, in the same manner as described in the simple compressed and impacted cases. It is interesting to note the early improvement which takes place in the paralysis, which is always present, and the amount of improvement is in proportion to the correction of bone displacement, provided actual destruction of the cord and nerve roots has not taken

place. The edema which occurs in such a contorted cord will be relieved with correction.

It is highly important that in this group of cases especially, a very careful neurologic examination be made and recorded previous to any reduction procedure. In complete severance of the cord, of course, no good can come of following such a procedure, but certainly in partial injuries, further damage to the cord due to hemorrhage and pressure edema can be averted.

The most severe and ticklish type of case to handle is the cervical fracture. It is indeed hard to diagnose cervical fractures from the average roentgenogram. The area is difficult to x-ray in the high cases at all times, and especially so when injured. Much help may be obtained from the following symptoms:

1. Pain, local and referred.
2. Tenderness on pressure at level of injury.
3. Muscle spasm with accompanying restriction.
4. Disturbance of posture, or angle of carrying the head.
5. Referred disturbance of skin sensation, especially of the arms.
6. Paralysis, variable, depending on the amount of cord or nerve root involvement.

#### TREATMENT OF FRACTURES AND DISLOCATIONS OF THE CERVICAL VERTEBRAE

Fractures of the neck are much more serious than those of any other level of the spine because they may result in instant total or partial paralysis; or because of lack of support of surrounding tissues, the liability to further damage by movement at site of fracture by unfortunate handling of the injured before fixation is accomplished.

Rarely do we see neck fractures without some cord or nerve involvement. They occur as a result of a blow on the head, or by falling on the head, and result in either:

*Hyperextension fractures*, the result of the force having been received with the neck hyperextended, usually resulting in injury to the atlas or axis; or

*Flexion fractures*, where the force is delivered with the neck flexed, usually resulting in a compressed and impacted fracture of the vertebral body.

It is very difficult at times to get satisfactory x-ray films of the atlas and axis, and even more difficult to interpret them. In some instances, when the symptoms are suggestive, even though the roentgenogram is not conclusive, it is advisable to go ahead with the full procedure of reduction and try to prove the presence of a fracture by later roentgenograms, when it is easier to handle the patient in a fixation cast.

*The Procedure of Reduction and Application of Fixation Cast for Cervical Fractures.* We are indebted to Böhler for the following very clear method of procedure:

Place the anesthetized patient on the table, which is especially fitted with arm supports. Böhler insists on a local anesthetic, since a much more accurate check can be kept on the condition of the patient throughout the procedure.

Next, while the head is held by the operating surgeon, who sits at the head of the table, the supporting board for the head and neck is placed in position. Stockinet is then placed in position, a piece to cover the head, small enough to conform to the neck. A larger stockinet is now placed on the body, extending from the perineum up and covering the entire body and shoulders, to which the head and neck piece is later sewed after the reduction has been accomplished.

Felt pads are then modelled to protect the occiput, chin, forehead, shoulders, and for the jacket portion of the cast, especially about the crest of the ilium, on which the jacket is built to rest.

The shoulder attachments to the table are now set. The Glisson sling is then placed about the chin and occiput and attached to the spreader. To the spreader is attached the spring balance, and this in turn is connected by block and tackle with the hook in the wall at level of the table. The supporting board is now lowered. Traction is then applied by means of the block and tackle, during which time the

head is held by the operator, with his fingers palpating the cervical spine. When the force of the traction is sufficient, between 15 and 35 pounds as shown on the spring balance, the operator will feel the reduction take place. If the fracture is the result of a flexion force, as in the compression type of fracture at a lower level, the operator may have to supplement a slight hyperextension force, whereas, if the fracture is the result of a hyperextension force, the operator will supply an added flexion force as the traction is applied. The traction is then slowly let up, and the narrow board pulled up sufficiently to support the head.

A roentgenogram is now made to see the result of the procedure. If satisfactory, the fixation cast is applied. If not, the traction and manipulation must be repeated, as well as the x-ray examination.

When the roentgenograms show a satisfactory reduction, the Glisson sling is removed, and with the operating surgeon continuing to support the head, with the supporting board withdrawn, the application of the cast is proceeded with. The stockinet is drawn together and sewed—the head piece to the body piece—the sheet wadding and the felt pads properly placed, and the plaster of Paris applied to include the entire body down to the pelvis. After the necessary trimming the patient is returned to bed.

It will be seen that the responsibility for the success of retaining the reduction rests entirely with the surgeon holding the head during application of the cast.

*After-Treatment of Cervical Fractures.* Because of the frequency of paralysis, a long period of rest in bed is necessary, and special care must be used to avoid contractures, deformities of the limbs, and the development of bedsores.

The use of splints and traction is helpful, as well as avoidance of the weight of bed coverings. Skin traction is not well borne in paralysis. A neutral position for splinting and traction is suggested to avoid strain.

Roentgenograms should be made sufficiently often to follow the progress in

bone healing, or to detect any change in the position of the fragments. If the latter has occurred, the fixation cast should be removed, reduction repeated, and a new cast applied.

When bone repair is sufficiently solid, the patient should be encouraged to become ambulatory, and as soon as possible the cast is replaced by a leather collar. Heat, massage, and supervised active exercises are then begun.

#### SPINAL INJURIES OTHER THAN FRACTURES OF THE VERTEBRAL BODIES

*The Intervertebral Disc.* In many fractures of the spine and other spinal injuries without recognized fractures, the intervertebral disc is injured. This may be recognized at the time of the accident, or later.

In many fractures of the vertebral body, especially in the compressed and impacted group, there is seen in the original x-ray film suggestion of disc injury. It may show a narrowing of the normal intervertebral space, or a deformity of either the superior or inferior plate of the vertebral body, a result of the injury to the disc. Later, the narrowing of the space becomes more pronounced, and there may even develop pressure symptoms on the cord, due to pressure from a posterior protrusion of an injured disc. An injury to the ligamentum flavae is also responsible for causing a like pressure.

The diagnosis of such a condition is very specialized and requires putting one of the bland opaque materials into the spinal canal to prove the existence of pressure on the cord. If found, a laminectomy is necessary for the removal of the offending tissue.

The treatment of this condition is rarely an emergency, and should never be undertaken except by one especially trained in such work.

The other less severe spinal fractures are:

1. Fractures of the transverse processes.
  2. Fractures of the spinous processes.
  3. Fractures of the laminae and facets.
1. The treatment of fractures of the transverse processes is of little moment

except that they do, when multiple, cause a prolonged disability. When uncomplicated, they rarely require other than bed treatment, preferably on a hard bed. They may or may not reunite, depending upon the amount of separation, and they may or may not cause a long period of pain. A precautionary measure in the treatment by bed rest, is to relax the tension on the muscles attached to these processes, and since the iliopsoas is one of the chief muscles attached to them, a pillow under the knees to assure relaxation is advisable.

2. Fractures of the spinous processes are of more importance since they may be responsible for deformities, as well as prolonged disability, and are not so rare as we have been led to believe.

They occur most frequently at the base of the cervical or upper dorsal region, either as the result of forced flexion, or by direct muscular action.

Attention is usually drawn to the injury by localized pain with decreased ability to straighten or hyperextend the neck, and frequently by the presence of a sulcus, where there has developed a tear and a separation in the ligamentum nuchae.

The x-ray examination will disclose a separated spinous process, which may be drawn downward for a distance of more than the width of the spine, so much so, that frequently it is missed in the roentgenologic examination unless especially looked for.

If the separation and damage of the soft tissues are sufficient to interfere with a proper, erect carriage of the head, an operative repair of the torn ligamentous tissue, with removal of the separated spinous process is advised.

3. Isolated fractures of articular facets are difficult to recognize, due to difficulty in the past of obtaining sufficiently clear roentgenograms of such areas, and also to the fact that congenital anomalies are hard to differentiate. Such roentgenograms should be made at an angle of 45 degrees.

When proved, plaster cast fixation for a period of about ten weeks is advised; a fusion operation is even more satisfactory.

# SURFACE DEFECTS OF THE HAND\*

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**S**URFACE deformities of the hand† can usually be successfully repaired with free skin grafts which have given satisfactory results. However, a loose, unwieldy pedicle flap, unless, of course, there is the loss of deep substance that requires the thick fat pad of a flap.



FIG. 1. A, widespread superficial burn of hand and arm (also face) treated with gentle debridement and open surgical drainage. B, healed in eleven days because there was no full thickness loss of skin.

isfactory results many times where the use of a pedicled flap might have been thought necessary. The close, glove-like fitting of the free graft seems to be superior to the

†The repair of tendons and nerves is a separate subject in reconstructive surgery of the hand, and the extensive reports of Koch and Mason may be referred to.

*Superficial Burns.* A fresh burn of the hand can probably best be managed by open surgical drainage, using wet packs or grease gauze, rather than sealing the area as with tannic acid or plaster of Paris. The open method allows early determination of the depth of the loss and movement of the joints, and, if there has been no full

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thickness loss of skin, early healing and return to function can usually be obtained by simple debridement of the dead surface

and the entire hand kept in the position of function. The average burn should be ready for grafting in three weeks, if ten-

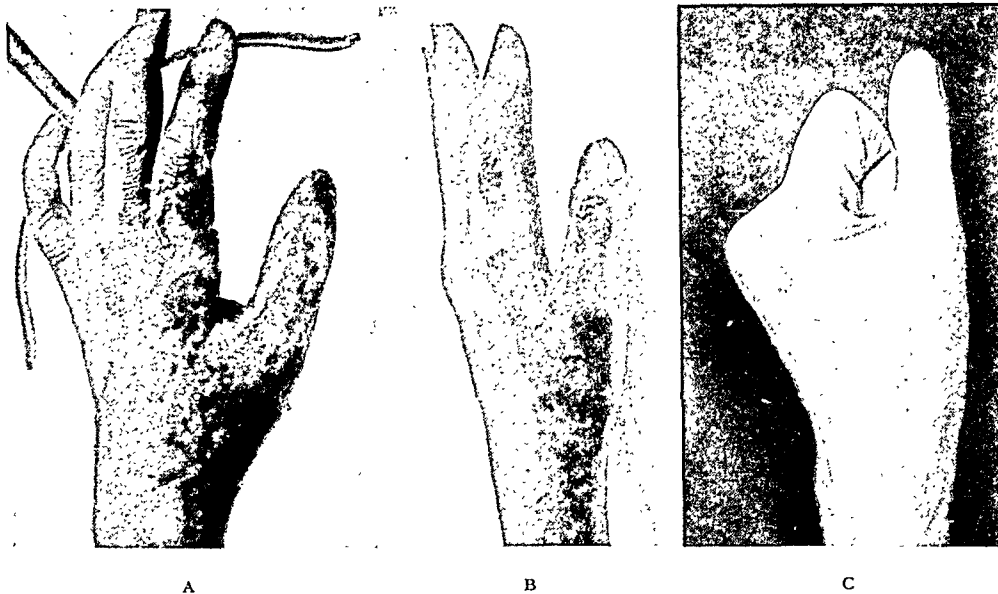


FIG. 2. A, one month after laundry mangle injury and burn. B, two days later, after gentle debridement and saline dressings. Operation performed three days later, at which time the granulations were carefully cut away down to a firm base, and the entire area was covered with a single large, thick split graft. C, complete and permanent function shown after four years. (From Brown, in *Ann. Surg.*, 107: 952, 1938.)

and keeping the hand clean and comfortable. If infection does develop in this type of wound, or if the hand is neglected and left out of the position of function, a marked crippling may result from deep fixation of tendons and joints, and possibly from loss of the skin itself from infection. (Fig. 1.)

**Fresh Deep Burns.** When the full thickness of the skin has been lost, even over small areas, in such a kinetic region as the hand, the indication for treatment is to restore this loss as completely and as soon as possible. The first treatment should be soap and water cleansing and gentle debridement; then the hand should be wrapped in fine-mesh grease gauze and bandaged. A daily saline soak from one-half hour to an hour and a new dressing with further debridement can then be carried out until the wound is ready for grafting, when it is best to discontinue the use of grease dressings if possible. Active movement should be encouraged during the soak, the fingers should be dressed apart,

and the entire hand kept in the position of function. Frequently the single application of a split graft may be all that is necessary. If there has been an extensive deep burn, it is often advisable to "dress" the wound with a thick split graft as soon as sloughs are separated and the granulations are clean, so that healing may stimulate activity and joint fixation may be limited; later thicker repair can be done if necessary. (Fig. 2.)

In "dressing" the areas with a graft, there will be parts that will regenerate the surface anyway, but the graft is put over the entire area for assurance that the raw areas are covered, and it can later be cut away from the healed surfaces.

**Late Unhealed Burns.** If losses have been very widespread, there may be repeated ulceration and permanent healing may never occur. The plan of restoration in patients with open wounds is to graft these areas first so that the region will be clean when the hand is opened for correcting the deformity.



*Late Deformities Repaired with Free, Thick Split Grafts.* Many late deformities can be repaired by carefully dissecting the

sebaceous collections may have to be emptied by pressure or small incisions. However, the grafts usually clear up so



FIG. 3 A, widespread deep burns of the dorsum of both hands; corrected by careful dissection of the scar without damage to the tendons and covering each area with one large split graft. B and C, complete permanent function three years later. (From Brown, in *Ann. Surg.*, 107: 952, 1938.)

scar so that complete correction can be obtained with little or no tendon exposure, and then covering the defects with thick split grafts.

The split graft is cut one-half to three-fourths the thickness of the skin deep—if possible, in a single piece large enough to cover the entire area. It is sewed on at about normal skin tension with running horsehair sutures all around, usually with the graft overlapping the wound edge, and basted through the center after multiple stab holes are made in the graft for drainage. (Fig. 3.)

If ulcerated areas such as Roentgen ray burns are grafted, the first dressing is kept wet with irrigating tubes incorporated in the dressing, for four days. This plan of wet dressing is open to question, but, for the present, it seems to be the safest for success of the graft, in most contaminated areas. The general details of splinting and dressing are described later under full thickness grafts.

The split graft is rough at first; the fine silk ligatures may work through to the surface, and have to be removed; and many

that in six to eight months they cannot be distinguished from a full thickness graft or even normal skin in some instances. (Fig. 2.)

*Details of Full Thickness Grafts.* Although there seems to be no actual measure of advantage of final function of the full thickness graft, it is often relied upon where widespread clean dissection and removal of the binding scar can be accomplished.

At operation, as on the patient in Figure 4, the scar is very carefully dissected from the underlying tendons; rough, forceful flexion of the wrist (or any other joint area that is being opened) will tear the scar overlying tendons and cause undesirable exposure of the tendons themselves. The scar is removed in layers if necessary, with cross-cuts in small areas to allow stretching. The contracted tendons have to be gradually pulled out so that complete flexion can be obtained if possible. It is even advisable to leave a thin layer of scar on the tendons rather than expose them, if a free graft is to be used, because the graft will not grow on a large area of exposed tendons. When all relaxation pos-

sible has been obtained, the hand is fastened to the wire mesh splint as illustrated, or to an aluminum splint prepared ahead of time, using sterile adhesive or

hand is shown in Figure 4D after three weeks' time, with a full take of the graft; it is now ready to be removed from the splint, and function can be started.

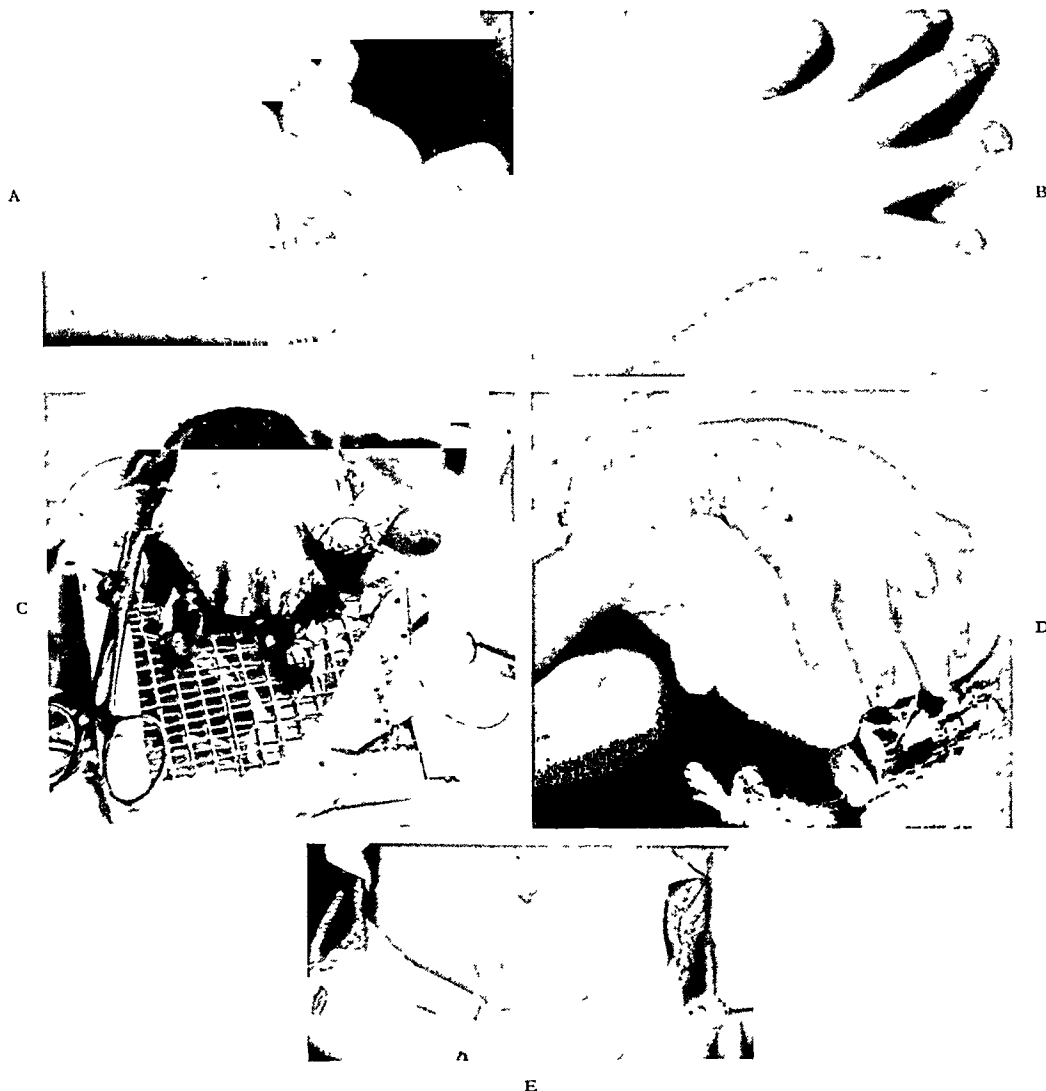


FIG. 4. A, complete extension deformity following a widespread full thickness loss of skin, with thumb and fingers definitely out of position of function. B, full restoration of function after careful dissection and coverage with a single full thickness graft. Shown after two years to indicate the permanence of the result. There is complete flexion of the wrist and all carpal joints. C, method of fastening hand to wire (or solid aluminum splint) with sterile adhesive and of application of the graft (three hours' operative time). D, three weeks after operation; full take of graft; arm being taken off splint. E, abdominal defect healed by direct suture. (From Brown, in *Ann. Surg.*, 107: 952, 1938.)

wires through the ends of the fingers. The splint is bent to throw the wrist and fingers as far out of the former contracted position as possible and an accurate pattern of the defect is cut. A full thickness graft is then sutured all around the edges and up on the fingers. (Fig. 4c.) The

If the defect will not open completely at the first attempt because of tendons that are too tight or for fear of exposing too much of them on forced manipulation, then whatever areas are open are grafted, and further freeing and grafting is done subsequently. If tendons are lost and have

to be replaced, or if they are too much exposed, then the advisability of using a thicker pedicle flap must be considered. (Fig. 7.)

The hand in Figure 5A has a complete flexion deformity and webbing of the fingers. Restoration was obtained with one full thickness graft and two subsequent

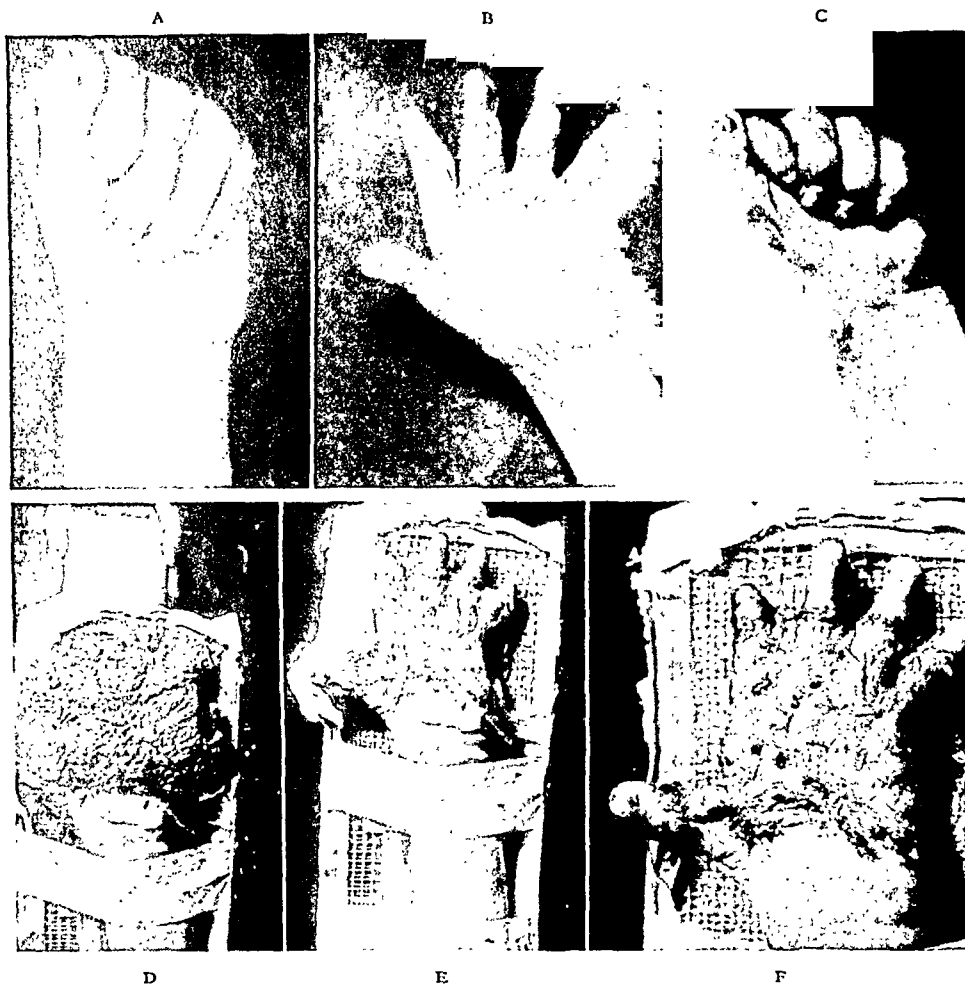


FIG. 5. A, complete flexion deformity and webbing of the fingers several years after a burn. B and C, full function obtained with one full thickness graft and two subsequent procedures to relieve the webbing. D, hand shown at time of first dressing with moulded marine sponge in place. Dorsal surface well padded. E, fine mesh, grease gauze next to the graft which is dry, indicating full take of the graft. F, full take shown with edge sutures; individual mattress sutures through the surface; stab-holes through the graft; and fingers held extended with silver wires through each tip and held to the wire splint. (From Brown, in *Ann. Surg.*, 107: 952, 1938.)

*Palmar surface losses* can nearly always be repaired with free grafts. Deep losses along the fingers may require thicker flap repair, but full function in one of these is seldom obtained. The contracted single finger, especially in a child, that shows keloid formation, may be one of the hardest deformities to repair, and careful consideration should always be given this apparently simple lesion.

operations for the release of the webs. (Fig. 5B and C.)

The question of late function of a free graft in the palm might well arise, and, in the answer, the anatomy may be considered. The skin and subcutaneous tissues of the palm are different from those elsewhere; for normal function, the thenar pad is essential, the thumb must be as strong as the fingers and normal position and

movements of the fingers are all-important. When this area is resurfaced, the skin necessarily must come from another part of the body and it always retains its original characteristics and does not change into the type of skin of the sound palm. The grafts shown here have stood up under the patient's requirements for as long as eleven years, but if any work proves to be too strenuous, there is little that can be done other than have the patient wear a glove for protection. In this instance, substituting a pedicle flap would seldom be of benefit because the difference of the skin surface would be the same as in the free graft.

*Preparation of Bed for Graft.* Figure 6 shows the freeing obtained by removal of the transverse, heavy scars and then careful dissection backward of the palmar flaps without damage of the nerves or complete exposure of the tendons. The edges of the defects are not straight lines but have darts in them to allow maximum replacement of skin. If a straight, narrow graft is put in a child's finger, a possible keloid along the edge may produce deformity. The palmar flaps are utilized in making new interdigital spaces and for part of the finger coverage, and then patterns of the defects are cut in thin sheet lead. (Fig. 6c.) Careful hemostasis is done with pressure and ligatures of white 000 silk.\*

*Cutting the Graft.* The patterns are outlined on the inner side of the thigh and an incision is made just through the skin. (Fig. 6f.) Elevation of the full thickness of the skin is then accomplished, using small forceps or gauze traction on the graft and some countertraction on the edges of the donor area to prevent any subcutaneous fat from adhering to the graft. Some small particles may persist which may be removed with scissors later—if these would

retain their viability, they would be of great advantage. (Fig. 6g and h.)

*Application of Graft.* For a successful correction in one operation, it is necessary that the entire deformity be opened and the hand maintained in complete correction during the period of healing of the graft. This point is almost as important when a pedicle flap is being employed and will be referred to later in Figure 7. The hand is fastened to a wire or aluminum splint with sterile adhesive or wires through the finger pads with the fingers extended, and can then be handled much more easily. The graft is sewed accurately into place all around the edges in order to favor obtaining primary union; where edges are too loose to allow a normal stretch of the graft, reefing sutures may be taken to pull the edges back away from the defect. The tension with which the graft is sewed on is best described as normal skin tension, that is, not pulled tightly like a drumhead, or left so loose that it may wrinkle. (Fig. 6d.) If the graft is larger, it is held down to the bed with additional mattress sutures through the surface. (Fig. 5f.)

*Dressing the Graft.* A few drainage holes are put through the graft and one layer of fine mesh, greased gauze (5 per cent scarlet red, xeroform or zinc oxide) is placed, very smoothly, next to the graft. Over this one or two gauze flats are placed and soft mechanics' waste is packed carefully between the fingers. Over this, more of the soft fluffed mechanics' waste or a soft, bleached, "wool-form" sea sponge is placed and bandaged firmly in place. A board splint is added for stability and the ends of the fingers are left visible. Figure 5d, e and f shows a hand at the time of the first dressing, done eight days after operation. There is a full take of the graft with no sign of infection, but dressings must be maintained for two weeks longer, using wet applications if inflammation should occur, and otherwise continuing with the greased gauze. The sutures can be removed at the first or later dressings, and there may be an apparent delay in healing because so

\* All possible skin is saved and utilized in making these repairs, and flaps may be shifted some distance, but the so-called z-plastic, in which scar webs and bands are entirely depended on to obtain relaxation and function, has not been relied on in any patient in this series.

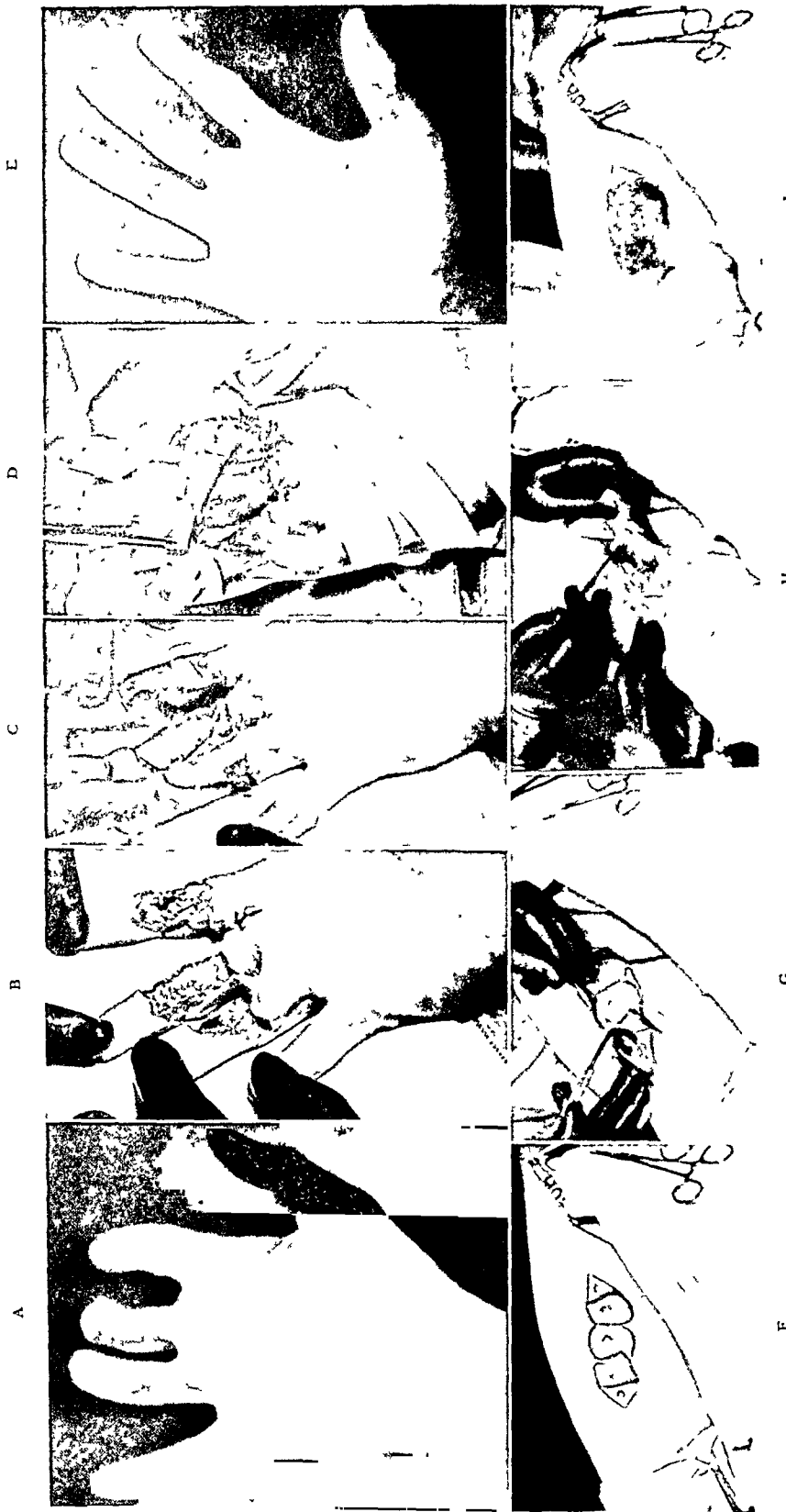


FIG. 6. A, flexion deformity of fourteen years' standing. B, careful opening without damage to nerves or tendons; careful hemostasis; fingers can be straightened. C, the interdigital spaces have been made out of the contracted palmar skin. Lead patterns have been put through the surface if necessary. D, the graft is sewed accurately all around the edges of the separate defects, and patterns sutured are put through the surface if necessary. E, result three months later. Patient satisfied with function, which is apparently normal. F, the patterns have been traced and outlined through the skin of the inner part of the thigh. G and H, the full thickness of the skin is raised with as little damage as possible, using fine forceps and gauze for holding. No fat is taken up on the graft. I, the graft is free and the resultant wound can be sutured or covered with a split graft from an adjacent area. (From Brown, in *Ann. Surg.*, 107: 952, 1938.)

much of the surrounding, heavily keratinized skin comes away.

The splint is usually maintained for

do joint movement any good. If there is tendency for contraction after this period, the patient is usually allowed to go about



FIG. 7. A and B, shotgun wound of hand with repair by a direct pedicle flap from the abdomen. Hand splinted to give traction for the fingers, and thumb rotated. Same splint used after hand is detached to obtain joint motion and maintain traction. A small wound of entry on the palmar surface was left to close itself. C, result is a hand that is far superior to any prosthesis that might be devised. (From Brown, in *Ann. Surg.*, 107: 952, 1938.)

three weeks and then movements are gradually restored. This long fixation, which is primarily for the graft, helps the tendon lengthening also, but it does not

his activities during the day, and at night the dorsal splint is reapplied, using either an aluminum one or a simple one made of wood and held on with adhesive.

**Roentgen Ray Burns.** In repairing Roentgen ray burns, wide excision and immediate grafting with thick split skin grafts will give the most consistently good results. If ulceration is present, or if there is bone or tendon exposed in the fingers, amputations may have to be performed, or a pocket flap from the thigh or abdomen resorted to, but, with the promise of success by early widespread free skin grafting, most patients should fall short of this degree of neglect.

There have been so many failures with immediate free grafting of Roentgen ray burns that many surgeons prefer to excise the lesion first and then later graft a fresh granulating bed. There is, also, serious argument against immediate grafting or application of flaps in any patient with a history of repeated infection or evidence of deep inflammation about the area. These areas should probably all be excised first, and repaired later, to avoid as far as possible, serious crippling infection. The full take of an immediate free full thickness graft on a Roentgen ray burn area is so questionable that it is seldom employed.

**Complete Amputation of Finger Tips.** It is thought that where there has been a clean amputation of a finger tip, immediate suture should be performed if possible. Crushing losses are not so likely to give good results, and immediate free grafts can be utilized or a pad supplied later by a simple flap from the palm.

**Wringer and Other Laundry Machine Injuries.** Fairly frequent injuries are seen from catching the hand in electric wringers, and there is usually a large flap torn away with its base distal; there is seldom any tendon or bone damage, and, in a child, the tear may not occur until the arm has come between the rollers.

Many of these cases can be repaired by immediate resuture, and, if it is possible to determine that viability of part of the flap is lost, this can be trimmed away and an immediate free graft applied. If a large flap is entirely off but still clean, it may be prepared as a free graft and used.

Other laundry injuries may have tendon, joint or bone damage, so that pedicle flap repairs become necessary.

**Pedicle Flap Repairs of the Hand.** There are definite indications for the use of thick pedicle flaps in hand repairs, such as: deep Roentgen ray burns of the dorsum; gunshot wounds; any deep wound that exposes too much tendon, bone or joint; or any late repair that will subsequently need work on tendon or bone and which could not be accomplished with just a free graft restoration of the surface. A broad or double pedicle can nearly always be arranged so that the flap does not have to be delayed.

Probably as many pitfalls occur in the use of flaps as in free grafts, and patients are frequently seen with inadequate flaps, bunched up in a pad on the hand, only replacing part of the deformity.

One of the necessary uses of a flap is illustrated in the gunshot wound in Figure 7A. Amputation had been considered, but it was suggested that at least an attempt might be made to save the hand. Accordingly, after eight days of cleaning the area, a direct flap from the right lower quadrant was sewed in place. The result (Fig. 7C) is a hand that is useful in all housework, far superior to any artificial one, and superior to any possible result that could have been obtained with a free skin graft.

**Occupational and Physical Therapy.** Following surface repairs in which there has been no deep involvement, if a good result can be obtained and the patient is fairly interested in his recovery, very little else need be done about his rehabilitation. Children usually work out their own problems, but if much joint stiffness has developed, considerable difficulty may be experienced in getting it out of the metacarpophalangeal joints, especially in women who are not likely to need this joint completely flexed. Simple work in the home with the early use of rubber sponge exercise in closing the hand, and such grosser movements as sweeping, shoveling, etc., may quickly loosen the joints. Manipulation to

swing thumbs around into place may be done frequently, but forced manipulation of these joints rarely produces anything but more stiffness. Elastic traction and rotation of the thumb, as illustrated in Figure 7 and as advocated by Koch and Mason for rehabilitation in deeper repairs, will produce the quickest freeing of joint fixation. The finer movements of the interossei and lumbricals can be greatly stimulated by occupational therapy, and many excellent results may be obtained. Secondary operative procedures on the metacarpophalangeal joints may occasionally be of benefit and very badly dislocated phalangeal joints may be resected or an attempt at arthroplasty instituted, but the indications for this last procedure are very infrequent.

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# EMERGENCY TREATMENT OF FRACTURES AND FRACTURE-DISLOCATIONS OF THE ANKLE

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WHEN one considers the relatively high incidence of fractures about the ankle joint and the extreme degree of disability and dysfunction subsequent to malunion, injuries of this region assume a major importance. Too often fractures in this area are regarded as "simple fractures"; on the contrary a higher number eventuate in malunion or dysfunction than is commensurate with the type of injury. If these fractures are given due consideration and adequate treatment, the percentage of disability can be materially reduced.

It should be emphasized that fractures and fracture dislocations about the ankle are emergencies and should be treated as such. Immediate reduction and immobilization are desirable; restoration to proper anatomic position is considerably less difficult, maintenance of reduction easier and the end results commensurately better. If reduction is delayed for twenty-four to forty-eight hours, swelling and fixation of the soft tissues make reduction a much more difficult problem.

It is an old axiom in the treatment of fractures, particularly those adjacent to or involving joints, that future function depends upon the approach to anatomic reduction. A study of end results of fractures of the ankle will verify the accuracy of this statement. With the entire weight of the body transmitted through this joint, the closely fitting articular surfaces necessitate accurate reposition for maximum efficiency. After union has partially or completely occurred, further closed manipulation is usually inadequate and may be disastrous; thus, it behooves one to secure accurate reduction of fresh fractures fol-

lowed by frequent observation to ascertain that the position of the fragments remains unchanged.

Roentgenographic examination of all acute traumatic injuries of the ankle is imperative: first, to differentiate between sprains and fractures; second, in obvious fractures to determine accurately the type of fracture and the true status of the fragments.

For purposes of discussion, fractures about the ankle will be classified as follows: (1) Monomalleolar—including the external and internal malleoli and fractures of the anterior and posterior margins of the tibia. (2) Bimalleolar or Pott's fractures. (3) Trimalleolar or Cotton's fractures. (4) Comminuted fractures of the articular surfaces. (5) Compound fracture-dislocations. (6) Fractures of the astragalus. (7) Dislocations of the astragalus.

## MONOMALLEOLAR FRACTURES

The simplest fracture about the ankle joint is a fracture of the external malleolus without displacement. Usually weight bearing can be begun in a snugly fitting walking cast as soon as the reaction from the acute injury has subsided. Too early weight bearing without support should not be encouraged.

Fractures of the external malleolus or lower third of the fibula with lateral displacement of the astragalus from an intact internal malleolus are accompanied by a rupture of the deltoid ligament. This is a much more serious injury than is generally recognized. Because the internal anchorage normally afforded by the deltoid ligament has been lost with improper treatment, a valgus deformity with widening of the

ankle mortice is not uncommon. The foot and ankle should be immobilized as for a Pott's fracture in a snugly fitting cast. As a rule, weight bearing should not be permitted until all reaction has subsided and a second well-fitting walking cast has been applied. The subsequent period of protection should be somewhat longer than for the ordinary Pott's fracture.

Fracture of the anterior margin of the tibia is relatively rare in comparison with other fractures about the ankle, usually being the result of forceful dorsiflexion of the foot. Since the small fragment of bone involves a minimal portion of the articular surface of the tibia, reduction can usually be accomplished satisfactorily by forceful plantar flexion of the foot with direct pressure on the loose fragment. Immobilization is maintained with the foot in slight plantar flexion until the fragment is solidly united. Rarely the fragment may involve a sufficient portion of the articular surface to necessitate open reduction, accurate reposition of the fragment, and internal fixation by a stainless steel screw or nail.

Isolated fractures of the posterior margin of the tibia are uncommon; the loose fragment which usually consists of only a small chip from the posterior articular surface can be replaced by dorsiflexion of the ankle alone. Immobilization is continued in this position. A fragment large enough to involve a large portion of the articular surface is usually associated with a Cotton's fracture.

Fractures of the internal malleolus or adduction fractures appear to be relatively simple injuries since the displacement is usually of a minor degree. Reposition, however, is much more difficult than it would seem. If these fractures are not anatomically replaced and properly immobilized, nonunion is frequent, and once nonunion is established the problem becomes increasingly difficult. Prior to a fibrous union the internal malleolus is practically a loose fragment except for its attachment to the deltoid ligament and little blood is derived from this source. Consequently, the frag-

ment undergoes aseptic necrosis from lack of blood supply, the bone becoming sclerotic and chalky. Such a status is not conducive to reestablishment of an osseous union even after open reduction, accurate reposition and the insertion of a graft or screw or a combination of the two; in several cases after a bone grafting operation, aseptic necrosis with persistent nonunion and disability continued, eventually necessitating removal of the internal malleolus and plication of the deltoid ligament. To avoid these complications, if the fracture cannot be properly replaced by conservative means, open reduction and internal fixation of the acute fracture are appropriate. The few disadvantages of open reduction are more than compensated for by the exact anatomic reposition.

#### BIMALLEOLAR FRACTURES

Bimalleolar, or so-called Pott's fracture, is the result of a force whereby the leg is fixed and the foot externally rotated and abducted; the astragalus is twisted in the ankle mortice, producing an oblique fracture of the lower end of the fibula. If the inferior tibiofibular ligament is stronger than the bone, the continued action of this force either ruptures the deltoid ligament or fractures the internal malleolus. The foot and the lower fragment of the fibula are as a rule displaced laterally on the leg and externally rotated with varying degrees of posterior displacement; the astragalus is displaced to the same degree as the fibula. This type of fracture will be referred to subsequently as the eversion type of Pott's fracture.

In contrast to the above fracture an abduction force alone wherein the foot is everted and the leg maintained in a fixed position results in a fracture of the medial malleolus or tear of the deltoid ligament with a fracture of the fibula at or just below the level of the ankle joint.

Adduction and internal rotation of the foot on the leg will produce a fracture of the fibula at approximately the level of the ankle joint or a tear of the lateral ligament

and, if the force is continued, a fracture of the internal malleolus of the ankle. The type of displacement is exactly opposite to

tibiofibular joint, usually associated with a fracture of the internal malleolus, or less commonly, with a rupture of the deltoid



FIG. 1. A, three months after bone grafting procedure for nonunion of internal malleolus. B, one year postoperative, nonunion is still present despite an apparently efficient technical procedure. C, due to continued disability, the internal malleolus, an aseptic sequestrum, was removed; the deltoid ligament was plicated to re-establish normal stability on the medial side of the ankle.

the eversion type of Pott's fracture, although not as extreme in degree as a rule.

Another type of injury, which is relatively uncommon, is diastasis of the distal

ligament. This fracture is the result of a combined abduction and external rotation force with the leg maintained in a fixed position. Since the distal tibiofibular liga-

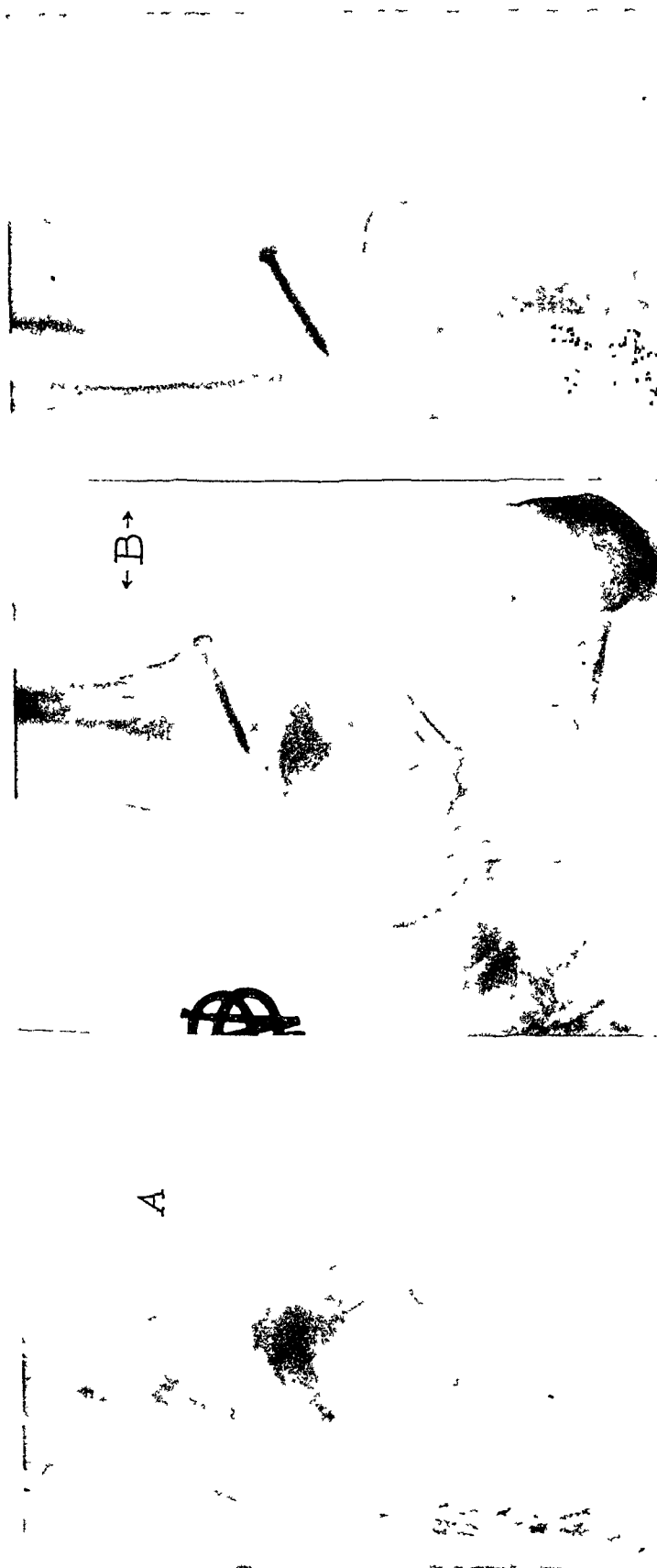


FIG. 2. A, trimalleolar fracture of the ankle with recurrence of the deformity in the cast. B, satisfactory reposition of the fragments after open reduction and internal fixation.

ment is relatively stronger than the bone, fractures are much more common than diastasis.

a new walking cast and then institute weight bearing. Many cases in which initial reduction was satisfactory have lost reduc-

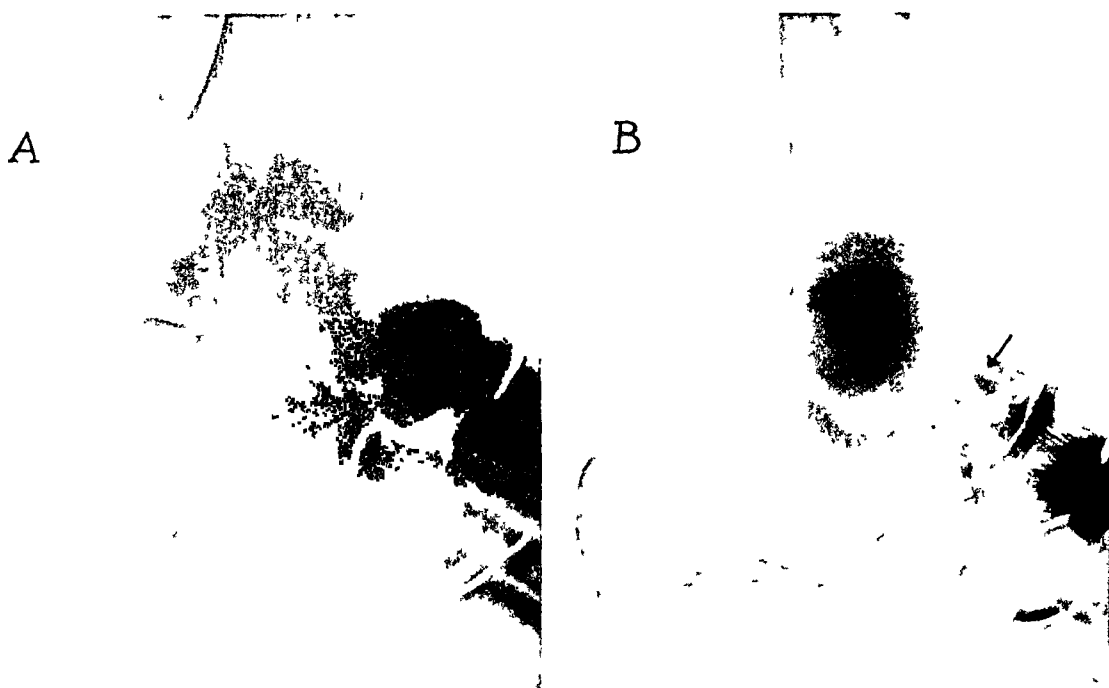


FIG. 3. A, fracture through the neck of the astragalus with complete dislocation of the astragaloscaphoid joint. The distal fragment was rotated 180 degrees in one year after open reduction and internal fixation by a homogenous bone peg

*Pott's Eversion Fracture.* Since both malleoli are bound to the tarsus, their displacement is of the same degree as the astragalus; thus, the foot, astragalus and both malleolar fragments may be considered as one unit which must be restored to its proper relationship with the proximal fragments of the tibia and fibula.

The movements necessary for reduction of the Pott's eversion fracture are the reverse of the forces which produce it.

Immobilization is instituted by a snugly fitting plaster boot cast which maintains the foot in slight equinus and marked inversion or varus. This is wiser than the immediate use of a walking cast; early weight bearing should be sacrificed always in favor of a positive maintenance of reduction. While early weight bearing is theoretically desirable, practically, it is preferable to wait three or four weeks until the fracture has partially solidified, apply

tion by weight bearing in a cast that has become loose as the swelling of the soft tissues subsided. Over-zealous patients or inexperienced surgeons who ignore this fact open the way for treatment of malunion; if the fracture is reduced properly, and maintained, satisfactory function will eventuate without early weight bearing. On the other hand, walking after partial union of the fracture is a convenience to the patient and is also of therapeutic value, being a means of preventing osteoporosis, possibly promoting an earlier union of the fracture, and lessening the length of convalescence following removal of the cast. Restoration of normal motion in the ankle and tarsal joints is secured more easily in patients who have walked than in those who have been immobilized without weight bearing.

If union has progressed satisfactorily ten weeks after the injury, an ankle brace with an inner T-strap to prevent eversion of the

foot is fitted. An arch support of leather and cork or steel is also worn inside the shoe to insure further slight inversion of

the inner T-strap is omitted from the brace and the arch support is usually unnecessary.

*Diastasis of Tibiofibular Joint.* Diasta-



FIG. 4. A, compound infected fracture of the astragalus; the remaining fragments are sequestra. B, after astragalectomy; infection precluded dissection necessary for complete backward displacement of the foot on the tibia.

the foot. The brace should hold the joint rigid for one month before motion is allowed in the ankle and should be worn thereafter for an additional two months. Use of the arch support may be continued for four to six months.

In elderly individuals or patients with extreme osteoporosis of the foot, physical therapy may expedite early active motion and aid in eradication of the swelling and edema of the foot following active weight bearing.

*Pott's Inversion Fracture.* The maneuvers necessary for reduction of a Pott's inversion fracture are considerably less forceful than those for the opposite type, though none the less exacting. Immobilization is maintained with the foot in neutral position, i.e., the foot at right angles to the leg and without inversion or eversion; eversion of the foot is not desirable and inversion of the foot tends to reproduce the original deformity. The subsequent after-treatment is similar to that for the Pott's eversion fracture with the exception that

sis of the lower tibiofibular articulation with fracture of the internal malleolus or rupture of the internal lateral ligament is a serious injury since maintenance of the proper apposition of the tibia and fibula is quite difficult by conservative means; even slight displacement of the fibula from the tibia widens the ankle mortise and allows an undesirable degree of laxity of the astragalus. This slight disturbance of the normal anatomy is sufficient to induce a traumatic arthritis. If forceful inversion of the foot and a snugly fitting cast are not ample to maintain proper relations between the tibia and fibula, some type of internal fixation is obviously desirable. This is most easily accomplished by a lateral incision over the lower portion of the fibula and the insertion of a vitallium screw through the shaft of the fibula into the tibia.

#### TRIMALLEOLAR FRACTURES

Trimalleolar, or so-called Cotton's fractures, consist of a Pott's eversion fracture, as described above, with an additional

fracture of the posterior margin of the tibia. From a practical viewpoint, small chip fractures which do not involve the articular

This is a very difficult task, if the posterior fragment includes as much as one-third of the articular surface of the tibia.



FIG. 5. End result after astragalectomy twenty-five years previously for comminuted fracture of the astragalus. No pain, good weight bearing position and sufficient motion for a normal gait despite lack of backward displacement and proliferative changes about the articulation. Such a result is the exception rather than the rule.

surface, or involve only a very small amount of the articular surface of the tibia, are not regarded as true trimalleolar fractures. Their treatment is similar to that of a Pott's fracture, since by the maneuver for a Pott's fracture, with forceful dorsiflexion of the foot, the small chip fragment is pulled down into proper position with the tibia by the posterior capsule and ligament. Further, since it does not involve the articular surface, or only a minimal amount, the possibility of an incongruous articulation need not be considered.

The true trimalleolar fracture which does involve a considerable portion of the articular surface is obviously a much more serious problem than an ordinary Pott's fracture. Here, not only must the relations be restored as for a Pott's fracture, but also the fragment of the tibia must be accurately or anatomically replaced and maintained in position to restore the articular surface of the tibia and provide a smooth surface for weight bearing and motion.

In trimalleolar fractures, if the posterior fragment of the tibia is large, the distal unit is not only displaced and rotated laterally and posteriorly but proximally as well. The maneuver for correction of this deformity is as follows: Traction is exerted in a distal direction to correct the proximal displacement of the astragalus and the fragment of the tibia which lies on the posterior surface of the astragalus; forward traction is then exerted and the foot simultaneously inverted, all the while maintaining the foot in equinus. If the fracture of the tibia includes only the posterior margin, the foot may be dorsiflexed to the neutral position. This will tend to bring the fragment down into normal relationship. If, however, the fracture involves one-third or more of the tibial plafond, the foot cannot be locked in dorsiflexion. When this maneuver is attempted, the posterior dislocation of the foot recurs from lack of support posteriorly. On the contrary, the foot must be left in partial or complete

equinus to prevent this occurrence. Post-operative roentgenograms may show satisfactory position in both views, only to show recurrence of the posterior dislocation after application of the cast, if the foot is not continually maintained in equinus with slight forward traction during the application of the cast.

In preference to this method of treatment, some authors use temporary immobilization in a splint with skeletal traction, the pin or wire being placed through the os calcis; after partial union, if the position is satisfactory, immobilization is instituted with a cast.

Even with satisfactory reduction, frequent roentgenograms should be made at intervals of one, two and three weeks to be certain that reduction is maintained. If there is recurrence of the deformity and the first procedure was carried out efficiently, further manipulation and reduction may be followed by a second recurrence of displacement. In view of the serious disability which follows malunion of a Cotton's fracture with posterior displacement of the astragalus, it is probably better to take a positive attitude and resort to open reduction, certainly after a second manipulation has failed, rather than delay until correction of deformity with preservation of a painless movable ankle is impossible. Experience has shown that once malunion is established, attempts at reduction and maintenance of a movable ankle result in a high percentage of failures; either the posterior fragment of the tibia cannot be brought downward into proper position, or if this is accomplished, the incident trauma results in degenerative changes of the articular surfaces and traumatic arthritis. Fusion is usually the final solution.

When open reduction is indicated, only the posterior fragment of the tibia, as a rule, is exposed. After proper anatomic reposition, the fragment is fixed by a metal nail or screw. Thereafter, reduction is accomplished as for a Pott's fracture and subsequent after-treatment carried out as described previously.

#### COMMUNUTED FRACTURES OF THE ARTICULAR SURFACE

"Explosion fractures," wherein the articular surface of the tibia and the external malleolus of the ankle joint are extremely comminuted, are the result of a downward thrust of the leg upon the ankle joint. Such injuries may be the result of a fall from a height, and may or may not be compound. The readjustment of the comminuted fractures to as near anatomic position as possible is as a rule an individual problem; the principles enumerated above, however, are useful and applicable to this fracture. In general, immediate immobilization in a cast which extends from the groin to the toes with the knee flexed, is preferable to suspension of the extremity in a Hodgkin's splint with skeletal traction exerted on the distal fragment by a pin passed through the os calcis. Motion at the fracture site is immediately eliminated, swelling and edema reduced to a minimum. Incongruity of the articular surfaces following such a fracture is the rule rather than the exception. A spontaneous fusion of the ankle in a good weight bearing position can be considered a very satisfactory result for such a fracture.

#### COMPOUND FRACTURE-DISLOCATIONS OF THE ANKLE

Approximately 95 per cent of fractures of the ankle are the result of indirect forces, the other 5 per cent being from direct force. Compound fractures are not uncommon in either group. The history and examination of the fracture should reveal the following information: The period of time which has elapsed since the fracture; whether the fracture is compound as a result of direct or indirect violence; the extent of the wound; and the extent of the injury to blood vessels, nerves, muscles and tendons.

In compound fractures the primary consideration is the prevention of infection. Accordingly, they may be classified



into two main groups. First, those that are seen early with relatively little soft tissue damage. Second, those with extensive macerations of the soft tissues and considerable foreign material in the wound, observed twelve hours or more after the injury. In the first group, after mechanical cleansing and débridement, the wound is closed with the reasonable expectation of not having an infection; subsequently, the treatment is that of a closed fracture, that is, manipulation, reduction and immobilization in a cast.

For extensively macerated wounds wherein the ankle joint and bones are exposed and considerable foreign material is present, the wound is irrigated and cleansed with copious quantities of normal saline solution. During this procedure all portions of the wound are gently massaged with the gloved hand in order to remove as much extraneous matter as possible. This procedure is of far more value in the prevention of infection than the douching of the wound with antiseptics. Strong, caustic solutions cannot be expected to sterilize the wound completely. Instead, the probability of infection is enhanced from coagulation of the proteins and necrosis of the superficial cells.

After a thorough débridement and removal of all devitalized tissue, the question immediately arises as to whether the wound shall or shall not be closed. There are no rules that are applicable to every case but in general the following suggestions are offered: If there has been an extensive amount of maceration of the soft tissues, considerable foreign material in the wound, and the fracture is of more than twelve hours' duration, thereby precluding the possibility of treating it as a closed fracture, drainage is always instituted. Reduction should be carried out at the time of the acute injury, or at least after a reasonable period of time following the determination that an infection will not occur; otherwise, there is little possibility of restoring the fragments to their proper

anatomic position. The foot and leg may be temporarily immobilized in an adequate type of observation splint with skeletal traction, particularly if the Carrel-Dakin technique is instituted. Otherwise, the fracture is reduced, a cast applied, and windows are cut in such a manner that the wound can be observed at frequent intervals; it is of utmost importance that gas or pyogenic infections be discovered in their incipency.

In the last two years sulfanilamide has been administered routinely in all compound fracture cases as a prophylactic for the prevention of both gas and pyogenic infections; the results of this treatment have been very favorable. While both types of infection have occurred, the infections have been less severe and virulent and have cleared up in a shorter period of time. Both from a medicolegal and therapeutic standpoint, it is wise to administer anti-tetanus serum, though there is considerable argument to the contrary. The use of the combined anti-gas and anti-tetanus sera has not been impressive.

#### FRACTURES OF THE ASTRAGALUS

There is little in the literature to guide one as to the proper treatment of fractures of the astragalus, and this abounds with a diversity of opinion. The low incidence, the high percentage of poor results, and the unusual anatomy and physiology of fractures of the astragalus present an interesting though confusing problem. The blood supply is notoriously scant and, therefore, the bone is subject to aseptic necrosis. Further, its large articular surfaces and numerous weight bearing facets afford plentiful areas for injury with a resultant traumatic arthritis. In considering these complicating factors it is easy to account for the varied ideas as to proper treatment.

The blood supply of this bone has not been completely worked out. The clinical evidence would lead one to believe that

the majority of the circulation enters the astragalus through the neck. This does not mean that fractures through the neck proximal to the principal source of blood supply will always result in a necrosis of the body but this factor must always be considered.

Fractures of the astragalus are classified according to anatomic location as those of the posterior process, the neck and the body. Fractures of the posterior process rarely cause any subsequent disability since the displacement is usually of minor degree and mere immobilization in a boot cast in the neutral position for six weeks will suffice for union in a satisfactory position. Small chip fractures in this region may be confused with an os trigonum.

Fractures through the neck without displacement are treated by immobilization alone. With displacement of the fracture, particularly where the head is rotated and displaced and the body rotated so that the fracture surface is in contact with the os calcis, more drastic measures are indicated. If the major portion of the circulation to the body is from the neck, certainly anatomic reposition and maintenance of this position is imperative. If conservative measures are inadequate, open reduction and internal fixation should be resorted to immediately, without waiting until malunion is established or the body of the astragalus has become an aseptic sequestrum. After open reduction, reposition of the fragments is anatomic; capillaries reform rapidly across the fracture site, reestablishing the blood supply from the neck to the body; internal fixation prevents any motion between the fragments which would disrupt this revascularization process. Internal fixation is obtained by a homogenous bone peg passed through a hole on the medial surface of the head, posteriorly and laterally into the neck and body.

The proper treatment of fractures of the body of the astragalus is a matter of varied opinion, the only point of agreement

being those fractures wherein there is little displacement; these are adequately treated by immobilization alone. In fractures of the body of the astragalus Miller and Baker believe that the fracture-dislocation can rarely be satisfactorily reduced by closed methods; that open reduction and reposition of the fragments permit an accurate reduction with less manipulation and manhandling of the fragments than conservative methods. Further, if entirely satisfactory reduction cannot be obtained, they believe that subastragalar arthrodesis should be considered as an early measure; first, to prevent subsequent traumatic arthritis, also as a possible source of blood supply to an impending aseptic necrosis of the body of the astragalus. They condemn astragalectomy as improper treatment with the exception of those cases in which the astragalus is an infected sequestrum.

According to Key and Conwell, when reduction cannot be effected by manual force, skeletal traction should be instituted through the os calcis and continued over a period of three or four weeks, then followed by a boot cast.

Other authors believe that in severely comminuted fractures of the body of the astragalus, excision or astragalectomy is the procedure of choice. Of ten patients upon whom Gray and Faulkner performed astragalectomy for this fracture, five obtained a stable and painless foot, in two the result was fairly successful and in three the outcome was disappointing.

While astragalectomy in adults with normal musculature has been successful in a few cases, the majority of the results have been disappointing; either the weight bearing position has been poor or the articulation has been painful. If possible, some other procedure is preferable, either surgical measures to restore proper position or conservative treatment. If incongruity of articular surfaces should result in pain after a year's trial of weight bearing with support, one always has recourse to fusion of the subastragalar joint or ankle joint

or both. A fused ankle in a satisfactory position is a relatively satisfactory, painless and stable weight bearing member. On the contrary, astragalectomy is performed without hesitation when the bone is an obvious infected sequestrum that blocks drainage and must be eventually extruded from the wound before healing can occur. These cases have turned out satisfactorily in that as a rule there is little or no motion between the ankle mortice and the articulating surface of the os calcis, fibrosis being so extreme as to end practically in a fusion or ankylosis. If the foot can be maintained in a satisfactory position during this period of fibrosis, a satisfactory weight bearing foot may eventuate. On the other hand because of continued infection, poor position as to backward displacement, or deformity, amputation may be preferable.

#### DISLOCATIONS OF THE ASTRAGALUS

Dislocations of the astragalus without fracture are relatively rare lesions. The mechanism of the dislocation is forceful plantar flexion of the ankle as would result from catching the heel on a step or curb, the astragalus being squeezed forward from the ankle mortice onto the dorsum of the foot. The circumstances of the individual case must dictate the treatment as to closed or open reduction.

#### SUMMARY

Fractures and fracture-dislocations of the ankle must be considered as emergencies and as such receive emergency treatment. While a certain amount of deviation from normal anatomy may be acceptable, in general, the end results are commensurate with the accuracy of the reduction. Recurrence of displacement after an accurate initial reduction is not uncommon, thus necessitating frequent observations to preclude malunion. Open reductions are appropriate when conservative measures are inadequate. The primary object of the treatment of fractures is the reposition of the fragments; if necessary, the beneficial effects of weight bearing are always disregarded in favor of maintenance of position.

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# ACUTE INFECTIONS OF THE EXTREMITIES\*

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IN any consideration of infections in the extremities one must consider certain differences between the upper and the lower. The hand is more subject to injury and may develop blisters or cracks in the thickened palm of those doing manual labor, whereas the foot is more likely to develop corns, calluses, perforating ulcers and ingrowing nails. The foot in relation to the heart is in a more distal and dependent position and is more likely to have an inadequate arterial inflow or an inadequate venous or lymphatic return flow. In the presence of infection both the upper and lower extremity should be elevated but this is more imperative for the foot. Rest and moderate elevation of the hand can be obtained by the use of a sling while in the case of the foot it is necessary to put the patient to bed to gain these ends. The hand is the more highly developed and complicated structure so that stiffness and scarring may result in great disability, while the foot and leg is a weight-bearing member, where tender scars and thin skin on the sole may be incompatible with satisfactory function.

In a discussion of acute infections of the extremities, as in any disease, the most important consideration is prophylaxis, but unfortunately the doctor is consulted only after the infection is well under way so his usual duty is treatment. He may, however, treat the larger injuries which form portals of entry for infection and by careful cleansing and débridement place the wound in such condition that infection will not develop. He also may have many opportunities to give timely warnings or advice as to how to avoid infections and

the public will, in time, profit through a general dissemination of knowledge.

Injuries, particularly puncture wounds, should be guarded against. This is especially important for those handling small children whose soiled diapers are held on with safety pins that must be inserted and removed many time a day. Possibly some day these dangerous insignia of early life will pass into the discard in the interest of greater safety for mothers and nurses. Any wound should receive first aid at the earliest moment, but if there has been delay in treatment and it seems that infection is likely to occur, the wound should be left open and dressed to facilitate drainage by preventing crusting and drying. Frequently this will stop the spread of the infection and promote early healing.

Small hangnails should not be pulled, since the cleavage plane extends deeper as it progresses toward the base of the nail. Where there is no tenderness and no break in the skin these should be trimmed short and sealed over with collodion. When the hangnail has extended deep enough to cause bleeding or serous drainage it should be trimmed short, but instead of being sealed over it should be dressed to facilitate drainage. Many an early infection in a small wound can be checked within one night if drying is prevented by a wet dressing or by a liberal application of an ointment beneath the dressing.

Sterile blisters or those caused by a fungus infection (epidermophytosis) should be treated so as to avoid contamination or secondary infection and when drainage does occur it should be free in order to

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avoid absorption and extension of the potential infection.

Every patient with any disturbance of sensation (nerve injuries, syringomyelia, paralysis, etc.) should be warned about the dangers of burns and injuries. Individuals with poor circulation, particularly when it is associated with some debilitating disease such as diabetes, or nephritis, should be cautioned as to the dangers of cutting corns, calluses, and ingrowing toenails. They should have their feet cared for by a physician who understands the dangers of the most trivial wound and can exercise aseptic precautions even when fairly confident that his treatment will not open a portal of entry for infection. With the slightest evidence of infection in such a patient treatment should consist of rest, both local and general, the best position to insure the maximum blood supply to the part, and local applications to facilitate drainage.

Fungus infections should be treated for the avoidance of blisters or cracks. The dead skin can be peeled off with salicylic acid and the fungus growth inhibited by applications of dilute solutions of iodine. When cracks or blisters occur every precaution should be taken to avoid secondary infection. When the fungus infection is acute the part should be kept dry and secondary infection should be guarded against. If secondary infection takes place free drainage should be obtained by the use of wet dressings or non-drying ointments to prevent crust formation.

After any infection has gotten well under way the treatment may be divided into four main divisions:

- I. Improve the resistance of the patient.
  - II. Provide free drainage at the proper time.
  - III. Prevent deformity.
  - IV. Restore function
- I. In seeking to improve the resistance of the patient we must consider:
- A. The general condition of the patient.

B. Local conditions in and about the area of infection.

- A. 1. The patient should be placed at rest both physically and mentally.
  2. He should take an easily digestible diet, rich in vitamins, giving adequate salts and nourishment, and with a minimum of waste products to be excreted.
  3. He should receive 3,000 to 5,000 c.c. of fluids every twenty-four hours, the exact amount depending on the condition of the patient, and the general temperature and humidity levels
  4. Elimination should be adequate.
  5. The hemoglobin should be maintained at as near a normal concentration as possible, by the use of diet, liver extract, and transfusions as indicated.
  6. The immunity should be increased whenever possible. This may be done by the use of specific immune serum when it is available. Multiple small transfusions may confer some immunity at times, in addition to maintaining the hemoglobin level
  7. Chemotherapy has in recent years assumed a place of great importance in infections. The most important drugs are sulfanilamide and the allied products for streptococcal, gonococcal, gas bacillus, and other infections; the arsenicals for the fusospirochetal infections that may follow human bites; and iodine and iodides for fungus infections. If there are no contraindications these drugs should be used whenever the organism is of a type which may be affected.
- B. In order to improve the resistance at the site of the infection any or all of the following local measures may be indicated.
- I. Rest. The patient should be kept at rest so that any massaging action on the infected area may

be avoided. Immobilization may be indicated, particularly if the infection is near a joint.

2. In addition to the patients having a normal quantity of blood, it is necessary to insure its maximum availability at the point of conflict between the organisms and the body. The body responds to the infection with a dilatation of the capillaries and smaller vessels, with a slowing of the blood flow, and the passage of leucocytes into the tissues. This hyperemia may be stimulated further by the application of heat, preferably as wet dressings, since these may be applied without the part being markedly dependent, as when it is soaked in a tub. The moisture also prevents crusting and facilitates drainage where there is a break in the skin.

X-ray is used at times in the treatment of certain localized infections. Aside from any effect it may have on the organism its principal action is in producing a hyperemia. When a fungus growth is harbored about the hairs or nails x-ray may be used for temporary removal of these structures. If properly given, the risk of a burn should be slight. A greater danger would be undue delay in providing adequate drainage following the local formation of pus.

Passive hyperemia, as advocated by Bier, may be beneficial, but care should be taken to see that the congestion is not too great since then it may do more harm than good. The dependent position causes a passive congestion which may result in increased edema and swelling and be detrimental to the defense mechanism. Unless used in moderation and with intelligence, passive hyperemia can do more harm than good.

3. Elevation. The part should be elevated in order to limit swelling and edema by favoring venous and lymphatic return flow. This also improves the circulation since too great swelling impairs not only the venous return but also the arterial inflow.

11. Provide free drainage. This may be used (A) in the very early stage of infection without surgical incision to prevent extension and abscess formation; or (B) in the later stages, after pus has formed, by a surgical incision to relieve tension, limit extension, and facilitate healing.

A. The wound of short duration with tenderness and evidence of early superficial infection, whether it be a large laceration or a hangnail, should be dressed to obtain the maximum drainage. Hot wet compresses of physiologic salt solution, boric acid, or magnesium sulfate are best, but if it is inconvenient to apply these a dressing with a liberal application of vaseline or an ointment with a vaseline base will prevent the formation of a crust. This encourages drainage and may prevent direct extension or a spread by way of the lymphatics or tissue planes and may obviate gross suppuration and abscess formation.

B. After a pocket of pus has formed it should be drained through an adequate opening or incision at the earliest moment, to stop the destructive process, limit infiltration and fibrosis, and prevent spread from one space to another. This is particularly necessary in such a complicated and delicately adjusted structure as the hand. The incision should be so placed as to avoid damage to important structures or opening of new cleavage planes to the infection, and should be large enough to insure free drainage with the minimal amount and the shortest period of insertion of drains since the latter may stimulate

fibrosis and the formation of crippling adhesions. After incision and drainage the part should be treated with hot wet dressings, but in the healing stage a dressing with an ointment to prevent drying may be used.

**Caution:** The principal pitfall in the use of compresses is the maceration of the skin with secondary transplanted infections such as boils or carbuncles beginning in the hair follicles. To prevent or minimize this danger the following precautions should be taken:

Wash the skin thoroughly with 70 per cent alcohol between compresses.

Periodically leave the skin exposed to the air for drying.

Mildly antiseptic compresses such as boric acid may be used. *Irritating chemicals, however, must be avoided.*

*The skin may be painted with gentian violet to inhibit the growth of the Gram-positive cocci.* This is particularly valuable in the axilla where the skin containing many hairs and glands tends to remain moist, making it difficult to avoid reinfection.

- C. Necrotic tissue should be removed with the minimal trauma. The sooner the dead tissue (fascia, tendon, bone, etc.) is removed the quicker healing will take place and the less infiltration and fibrosis there will be. However, there are many occasions when a wait for a natural line of demarcation is less damaging than the unavoidable trauma to viable tissue in the early removal of the dead part, such as a piece of bone.

III. *Prevention of deformity* is imperative if we are to avoid needless crippling disabilities. These are usually easier to avoid than to correct. Mobility of joints should be maintained if possible, and where there is danger of loss of mobility the part should be kept in the position of greatest functional use. The knee should be slightly flexed, foot drop should be prevented, the elbow should be flexed so the hand can be

brought to the face, head, chest, etc., the forearm should be between pronation and supination but with supination preferable to pronation, the wrist should be moderately extended in the position assumed with the maximum grip, the fingers should be in moderate flexion, and the thumb should be out opposite the palm and fingers in a position where it can be brought into apposition to the partly flexed fingers or be used for gripping an object in the palm. All too frequently we see patients with a long-standing infection of the hand who have had the part extended in pronation, with the wrist slightly flexed, the fingers fully extended and the thumb and thenar eminence in the same plane with the palm. Fixation in this functionally useless position can be avoided by the use of a splint for extension of the wrist, allowing flexion of the fingers. The palm support must not hold the thenar eminence and thumb in the plane of the palm but must allow them to assume their normal position of rest. Passive, and later active motion, should be used to maintain mobility in the joints as soon as the infection will permit.

iv. *Rehabilitation.* Much can be done to simplify rehabilitation by early diagnosis and treatment and by taking precautions to prevent deformities and fixation of joints.

When the infection subsides rapidly there is little need for treatment other than free drainage during the stage of infection. Following healing the part soon returns to a normal range of mobility as a result of routine use. When such rapid resolution does not take place and cannot be hastened due to the underlying pathologic condition, mobility of the joints should be maintained by passive and, at times, active motion. In some cases such motion causes a distinct improvement as a result of better drainage and a diminution in the swelling.

After healing is complete any stiffness or deformity should be treated by baking, massage, paraffin baths, and other physiotherapeutic measures. Contractures may demand traction or may have to be released

by surgical procedures, and missing tissue may be replaced by a suitable type of graft.

When a part is damaged beyond hope of repair and is a handicap to the best function of the remainder of the extremity, it should be removed. In the case of the foot this might require amputation if the body as a whole could be made to function better with a good artificial foot. In the case of the hand a stiff finger may be removed if sufficient motion cannot be obtained to prevent it from being a handicap for a given individual in a given occupation. Under no circumstances, however, should the thumb be removed if any part of it can be saved.

In the more serious and rarer types of infection (e. g., tendon sheath, etc.), it is essential for the welfare of the patient that he be placed under the care of a surgeon who has had experience in handling such conditions and can give him the greatest chance of obtaining complete recovery. Delay even of a day or two may mean permanent crippling which otherwise might have been avoided.

#### SPECIAL TYPES OF INFECTIONS\*

*Acute lymphangitis* with red tender streaks extending from the focus of infection up the extremity along the course of lymphatic drainage and associated with regional lymphadenitis and occasionally with chills and high fever, is well known and its gravity is fully appreciated by the profession and the public. Most frequently it is caused by the hemolytic streptococcus, but may be caused by other organisms.

The diagnosis of such a condition is evident, but we should keep in mind that there can be a lymphangitis of the deep lymphatics when there is no redness, but a diffuse swelling with tenderness along the

course of the deep lymphatics and with involvement of the associated lymph nodes.

Treatment demands rest, both local and general, elevation, and hot wet dressings to the wound of inoculation and the entire involved extremity. If there is localized pus formation free drainage should be instituted. The lymphadenitis may be treated with cold applications so long as there seems to be any chance of preventing suppuration in the glands. If the lymphangitis seems to be severe or is not definitely subsiding within twelve hours after treatment is instituted the patient should receive sulfanilamide, sulfapyridine or such allied product as seems indicated. With early treatment the prognosis is good. The acute lymphatic involvement subsides within twelve to forty-eight hours. In an occasional case there may be suppuration in the adjacent lymph nodes which may have to be drained. In some neglected cases, and occasionally in inadequately treated cases where the resistance is poor or the infection particularly virulent, the organisms may reach the blood stream, causing a septicemia. The infection is then generalized and must be treated as such. In occasional severe infections which do not become generalized there may be any degree of necrosis of tissue with abscess formation. Such abscesses should be drained and treated with hot wet dressings and all measures for combating the infection.

*Erysipelas* involving the extremity, similar to this disease elsewhere, is caused by a streptococcal infection in the skin lymphatics and should be treated by sulfanilamide or some related drug, preferably associated with the use of streptococcus antitoxin or serum. The general principles of treatment of infections should also be applied. When there is an associated lymphangitis and cellulitis with abscess formation these should be treated with hot wet dressings and the latter should have adequate drainage.

*Boils and carbuncles* are particularly likely to occur on the hands in the hair-

\* Detailed descriptions of the anatomy of the hand and the special types of infections cannot be covered in an article of this type. Illustrations also would be too numerous to publish. For illustrations, more detailed descriptions, and consideration of the more serious and special types of infections the reader is referred to Kanavel's pioneer work on the hand, to Lewis' "Practice of Surgery," Nelson's "Loose-Leaf Surgery," other textbooks of surgery, and the numerous articles in the literature.



bearing areas and occasionally may occur elsewhere on the extremities. As soon as pus forms they should be drained by a crucial incision, taking care in the case of carbuncles to undercut the flaps so as to open all the channels of pus, but not to incise so deep or so far laterally as to cut through the defense barrier, either fascial plane or zone of leucocytic infiltration. Every precaution must be taken to prevent transplantation of the organisms to other parts of the skin. These precautions are particularly necessary when wet dressings are being used.

*Paronychia*, a pyogenic infection in the tissues lateral to the finger nail, and *eponychia*, an infection of the tissue superficial to the nail root, occur most frequently secondary to a hangnail but may follow any puncture wound in this region. In early cases the infection may be limited to one side of the nail and not involve the eponychium, but in neglected cases the infection extends around the base of the nail, the popularly named "run around," and extends beneath the root of the nail which becomes detached and acts as a foreign body. (Fig. 1.) This foreign body together with inadequate drainage causes the condition to become chronic with a resultant growth of redundant granulation tissue which still further obstructs drainage.

*Treatment.* In the very earliest stages when a hangnail or puncture wound becomes "sore," wet dressings or maceration of the epidermis and dried secretion with an ointment may give free drainage and the condition may subside. In the somewhat more advanced stage the swollen soft tissues may be pushed gently away from the side or base of the nail with evacuation of a drop of pus. Following this the infection may subside with wet or ointment dressing. If there is not rapid improvement, however, free drainage should be secured by an adequate incision, performed preferably under nitrous oxide or cyclopropane anesthesia unless the pus is so superficial that it can be obtained without undue pain. When the entire base of the nail is involved

the nail root and all undermined parts of the nail must be removed. (Fig. 1.) An incision lateral to the nail root may or may not be necessary to secure free drainage. In some advanced cases where the nail root is completely detached it is possible to remove it without any anesthesia. The distal part of the nail should be left in place if it is not detached. Under no circumstances may an incision be made into the bed beneath the nail root since this will result in a split in the new nail. (Fig. 2.) The incision must not endanger the distal interphalangeal joint as a pyarthrosis and osteomyelitis would likely follow opening of the joint space.

*Ingrowing Toe-Nail.* In the foot an ingrowing toe nail predisposes to an infection in the tissues lateral to and beneath the edge of the nail. Here also the edge of the nail acts as a foreign body and must be removed. In the early stages infection may be avoided or allowed to heal if the edge of the nail is elevated by packing cotton beneath the edge. In certain patients the condition may be relieved permanently by this method if the nail is allowed to grow longer at all times. In the more severe cases it may be necessary to remove part of the nail and the matrix from which it grows. An incision demarcating the part to be removed is made through the nail, through the soft part over the root, through the root and the nail bed. The lateral part of the nail is removed along with all the matrix from which the removed part grows. The wound is thoroughly washed out. If infection is present the wound is packed open with vaselized gauze. Redundant granulation tissue should be removed. In the acute stage of infection drainage should be established, but it is unwise to remove the offending part of the nail if adequate drainage can be obtained otherwise. It is imperative that the incision not extend into the distal interphalangeal joint, a complication which I have seen. If free of infection the flap superficial to the nail root may be sutured back in place with one suture. When this is done close observa-

tion for evidence of infection is imperative. If this develops the wound should be opened and treated by wet dressings and other measures to control infections.

dorsum of the finger but is particularly susceptible to inoculation through puncture wounds. It is surrounded by a dense fascia which is attached to the bone by

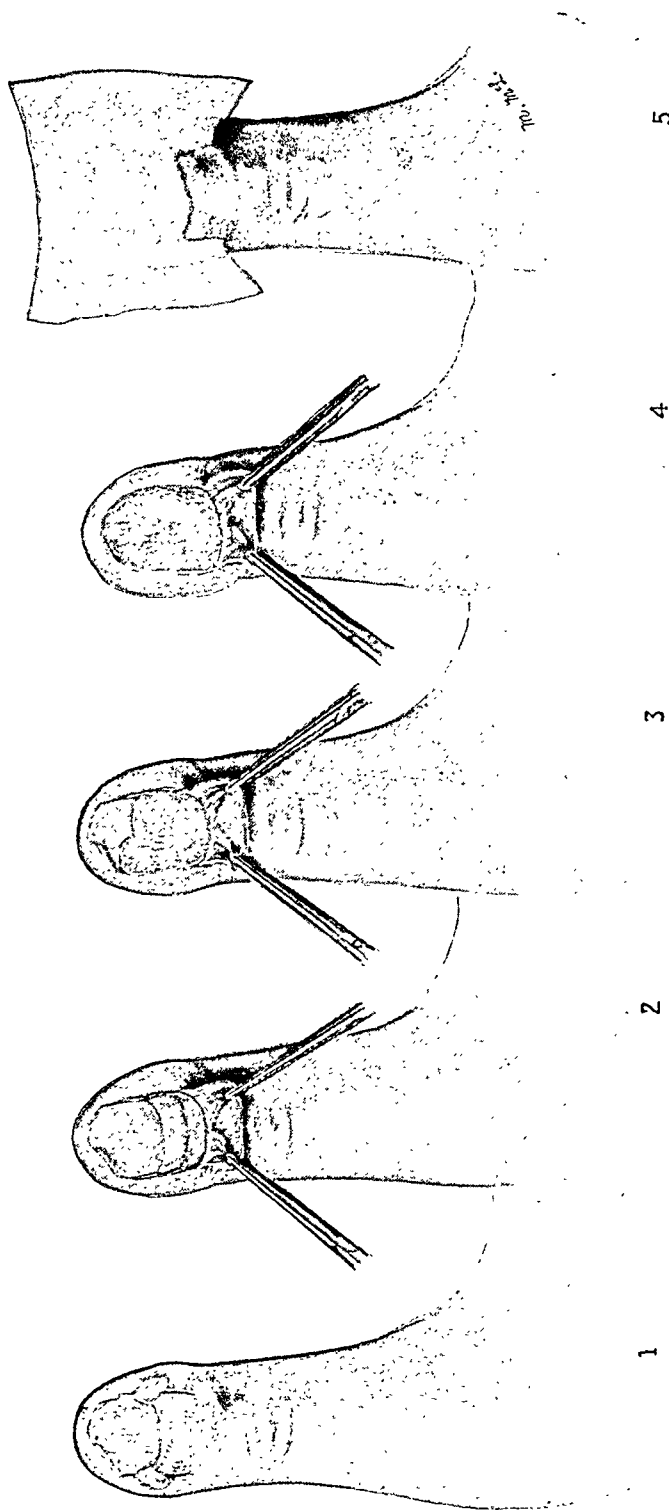


FIG. 1. Operation for paronychia with subungual abscess. 1, incisions to either side of nail avoiding matrix. 2, nail root exposed. Nail root may be removed without the lateral incision if free drainage can be obtained. 3, undermined part of nail cut away. 4, nail completely removed since the small fragment was not stable. 5, gutter percha or rubber placed beneath soft part flap to serve as drain.

The anterior closed space on the palmar side of the distal phalanx of the finger is well separated from the infections on the

fibrous strands. These divide the space up into pockets, may direct the pus toward the bone, limit the amount of swelling, thereby

causing an increase in tension which may be great enough to interfere with the blood supply in the vessels which pass through this space. The bone may be infected by direct extension or the osteomyelitis may be secondary to necrosis resulting from cutting off of the blood supply. A diagnosis as to the presence of pus must be based on the throbbing pain, tension, and exquisite tenderness on point pressure, since fluctuation cannot be elicited due to the tension and the small volume of pus present.

*Treatment.* Early incision with the relief of tension is indicated if extensive destruction of tissue and an osteomyelitis of the distal phalanx is to be avoided. Incision for drainage should be made on the side of the finger volar to the bone with care to avoid the nerves and blood vessels. The incision should extend through the fibrous trabeculae in the infected area. Only rarely may it be desirable to make bilateral incisions with through and through drainage. The horseshoe incision extending around the end of the finger with complete undercutting of the palmar pad leaving it as a flap is seldom justified.

The one exception to the use of the lateral incision is the presence of a superficial or subepidermal abscess on the volar aspect of the distal phalanx and not involving the anterior closed space (therefore not an anterior closed space abscess but may be confused with it). In treating such an infection, however, the possibility of a collar button type of abscess with part of the abscess beneath the fascia must be kept in mind.

*Infections beneath a callus* in the palm occur fairly frequently and should be treated by removal of the callus to provide free drainage. Such an infection may give marked edema of the dorsum of the hand since the lymphatic drainage is to the dorsum. The diagnosis, however, should not be confusing if one searches for induration and the point of maximum tenderness, and ignores the soft pitting edema. A careful examination must be made to rule out or confirm the presence of a collar button type

of abscess with an extension beneath the palmar fascia. Because of the difficulty in cutting through the callus and the extreme tenderness resulting from pus under pressure, general anesthesia may be necessary. Unconsciousness of the patient, however, should not give one freedom to use any more force or pressure than is absolutely necessary to remove the callus with the sharpest scalpel.

*Infection of the Foot in Diabetics.* In no field of medicine is the close coöperation of the surgeon and internist more imperative. Perforating ulcers on the feet in patients suffering from diabetes, with an associated trophic disturbance secondary to a neuritis, beginning beneath a callus, are usually chronic but may be the starting point of an acute infection. The patient with diabetes, particularly if in the older age group, not infrequently has an associated arteriosclerosis. The combination of poor blood supply and decreased resistance to infection makes any acute infection extremely serious since it is a threat both to the limb and to life.

Prophylaxis can be applied in such patients by keeping the diabetes under control and by seeing that they have adequate care of the feet with avoidance of or treatment for calluses, corns, ingrowing toe-nails, etc., avoiding if possible the formation of any portal of entry for organisms. Every precaution should be taken to avoid injury and infection. With the most trivial wound the part should be elevated and put at rest. Early infections should be vigorously treated and in every case of injury or infection the diabetes should be brought or kept under control if possible. With infection once well established moist gangrene is likely to follow if there is an impaired blood supply. Drainage should be established by warm wet compresses alone in the early stages and by incision and wet compresses if there is formation and localization of pus. The local circulation should be stimulated, but not by the use of pressure and suction methods.

So long as there is promise of bringing the infection under control every effort should be made to save the part. In many

ground in which organisms can grow. Of course every detail of aseptic technique as we now know it is also employed. No



FIG. 2. Split nail following an incision which injured the matrix.

cases there may be no loss of tissue or only the loss of one or two toes. When the loss of the foot seems inevitable it should be removed at such level as seems indicated by the blood supply. In any case there is danger of severe infection, most commonly with a streptococcus, gas bacillus, staphylococcus, occasionally tetanus bacillus or a combination of organisms, in the amputation stump, particularly if the amputation is below the knee. The organisms are probably in the tissues at the time of operation, having reached the operative site by way of the lymphatics, cleavage planes, or muscles. My personal choice of method of amputation is to try to avoid infection by giving the least favorable

tourniquet is used, and as few ligatures of the finest silk possible are used to ligate only the isolated blood vessels. Complete hemostasis is secured. No tissue is crushed, only sharp dissection is used, tension is avoided in closure, no drains are inserted, very few buried sutures are used, and these contain in the loop the minimal amount of tissue. Both the buried and skin sutures of silk are tied so loosely that slight tension will separate the approximated tissues, indicating that subsequent oedema will not produce strangulation. The dressings are applied snugly but should not cause any undue compression. If it is felt that such a closure is not feasible the wound is left open following amputation, is closed loosely

with through and through sutures of silver wire which allow drainage, or the amputation is performed at a higher level.

No compromise measures such as use of catgut, and insertion of drains are used since they will make the risk of localization of the infection and suppuration far greater. We try either to avoid any localization of bacteria or leave the wound open for the freest drainage. If infection does occur, in a patient whose general condition is good and there is an adequate blood supply, the wound should be opened for free drainage, hot wet dressings should be applied, the part elevated, and all measures for combating infection should be used. Secondary closure can be carried out later after the infection has subsided. In the presence of a somewhat diminished blood supply, at times healing can be secured by the use of skin grafts. When the area is covered with epithelium it can be treated as a clean wound and a plastic repair carried out to secure a good stump for an artificial limb.

If the patient's condition is serious, the circulation poor, and severe infection occurs in an amputation below the knee, the best chance of saving the patient's life may lie in re-amputation just above the knee, avoiding damage to large muscles and leaving the wound open for drainage and secondary closure. In any amputation in the presence of a moist gangrene with severe infection, tetanus and gas bacillus antitoxin and sulfanilamide should be used as prophylaxis against infection localizing in the operative wound.

*Gas Gangrene. Acute Infectious Gangrene.* Gangrene may occur when the blood supply is inadequate from any cause. If infection gains entrance to the deeper tissues moist gangrene may be precipitated in an extremity which otherwise might survive. Treatment should be similar to that given for gangrene and infection associated with diabetes, except that the patient's general and local resistance may be better, there may be a better chance of saving the extremity, and we do not have

the complicating diabetes to be kept under control.

*Severe infections* may occur anywhere in the extremities following severe or even trivial puncture wounds. These are likely to be most severe following compound fractures, or crushing injuries with extensive devitalization of tissues. I have seen such a result following a bullet wound in which a large amount of cloth or wadding was carried into the wound and not removed for several days. The type and severity of the infection depends both on the number and pathogenicity of the organisms and on the local and general resistance of the patient. All these conditions can be altered greatly by adequate first aid and many of the infections can thus be avoided. The most dreaded infections are those caused by the gas-producing organisms, the hemolytic streptococcus and hemolytic staphylococcus. All these infections may be influenced greatly by the recent addition of sulfanilamide and related drugs to our treatment by chemotherapy. In all severe injuries adequate prophylactic doses of tetanus and gas bacillus antitoxin should be given at the time of injury and should be used in larger therapeutic doses in case infection develops.

An infection with the gas-producing organisms may lead to gas gangrene, particularly when the wound is soiled, heavily contaminated, and the tissues, particularly the muscles, are traumatized.

Symptoms of gas gangrene are abrupt in onset, with a high temperature and rapid pulse, associated with restlessness, apprehension, general prostration, and an increase in the tenderness, swelling, and evidence of inflammation in the wound. Gas in the tissues, if subcutaneous emphysema from other causes can be ruled out, is diagnostic and may be detected by palpation, auscultation or roentgenograms. Drainage from the wound is likely to be serosanguinous, have a characteristic odor, and smears will likely show the large Gram-positive Welch bacillus. There are, however, a number of other gas forming organisms

which may be present alone but the wound flora will likely be mixed. Unless the specific organism causing the infection is

sulfanilamide should be given in large quantities, the wound should be opened widely for free drainage, and infected and

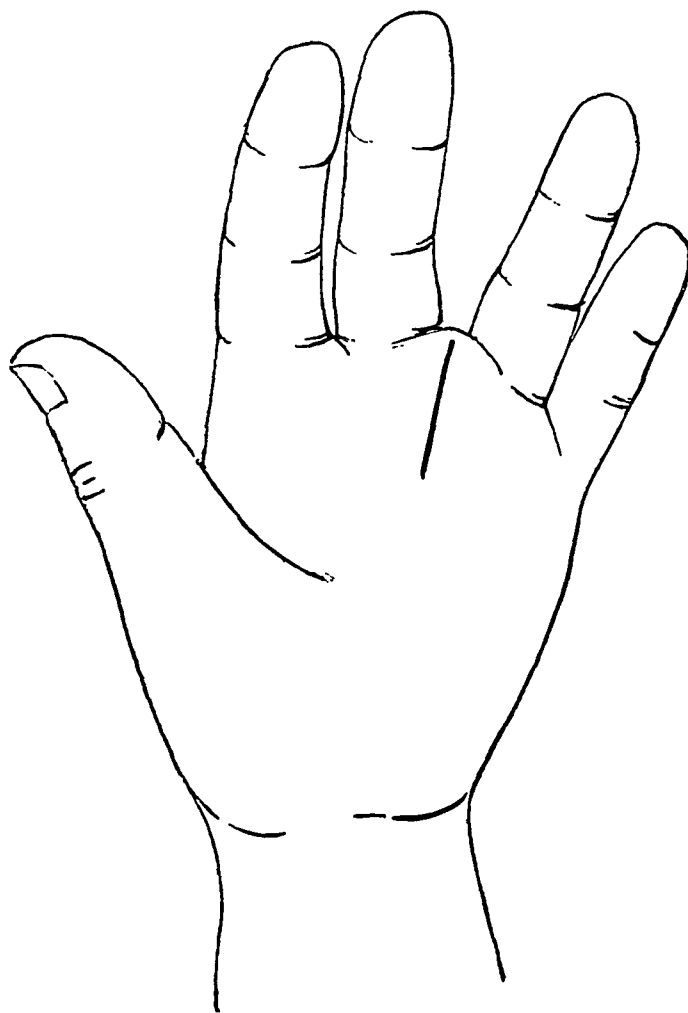


FIG. 3. Incision for draining a midpalmar space abscess presenting along a lumbrical canal in the interspace between the third and fourth fingers. The incision is placed distal to the vascular arches and between the vessels and nerves to the fingers. The palmar space is opened by inserting a clamp along the lumbrical canal, spreading this to give free drainage.

identified a polyvalent serum should be used.

The infection spreads principally along individual muscles though many of these may be involved, particularly if they have been damaged.

Prophylactic treatment consists in adequate care of the original wound along with the use of serum. Depending on the likelihood of infection, the patient may be given sulfanilamide as a prophylactic measure. After the infection has started, serum and

necrotic muscles should be removed. Even before the advent of sulfanilamide and associated drugs many of these patients were cured without loss of the extremity if the infection was not associated with a compound fracture. The percentage of patients cured without amputation should increase now that these new drugs are available. In the severe infections associated with compound fractures, in extensive infection associated with widespread damage to the tissue, and in the case of infections

in patients who put up little resistance, amputation may be indicated in order to avoid too great a risk of loss of life. The

Treatment of this subcutaneous gangrene consists in early operation as contrasted to other streptococcal infections

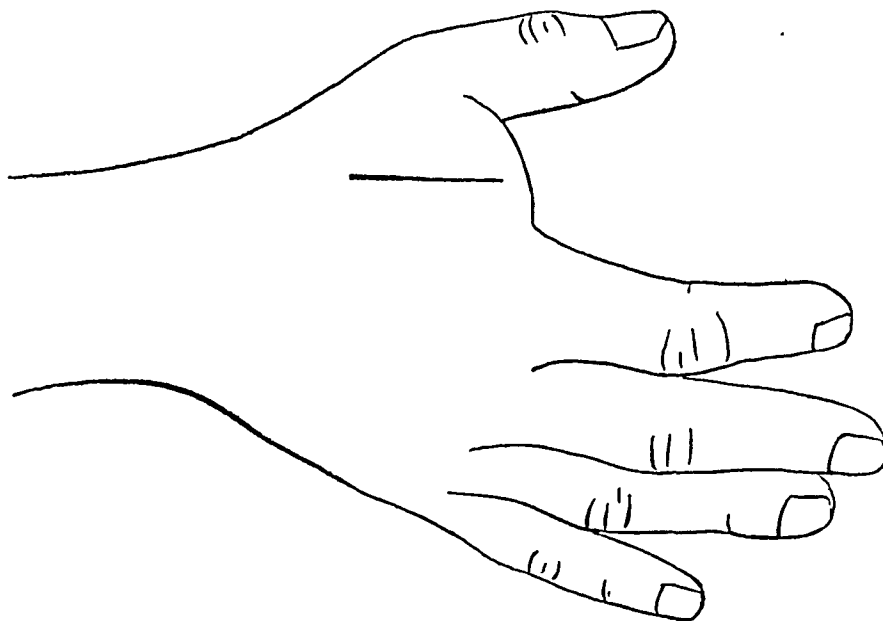


FIG. 4. Incision on the dorsum of the swollen web between the thumb and index finger for drainage of a thenar space abscess. The abscess is opened by passing a hemostatic forceps along the palmar surface of the adductor pollicis muscle to enter the abscess cavity. The drainage tract is enlarged by spreading the clamp.

amputation wound should pass through as few muscles as possible and should be left open for drainage. Treatment with tetanus and gas bacillus serum and sulfanilamide should be continued until the infection has subsided and all danger of spread has ended.

*Streptococcal infections*, when once established, should be treated by the use of sulfanilamide and anti-streptococcus serum, by adequate drainage, as soon as there is pus formation, and by all other methods of combating infection.

Rarely we may have gangrene of the subcutaneous tissue and skin caused by hemolytic streptococci as reported by Meleney and others. The wound of entry is usually trivial but may be severe. There is a rapid spread with extensive necrosis of the subcutaneous fat and a somewhat less extensive necrosis of the skin resulting from the thrombosis of the blood vessels supplying the area. There may be an associated septicemia and metastatic abscesses, in which cases the prognosis is grave.

when we wait for formation of pus. The incisions should extend to the edge of the subcutaneous necrosis. Hot wet dressings, sulfanilamide, and all methods of combating the infection and supporting the patient should be continued.

*Hemolytic staphylococcal infections* may be quite serious and should be treated by all the methods of combating infection and increasing the resistance of the patient that are at our disposal. In addition, staphylococcus antitoxin and sulfapyridine are very beneficial. When the infection is severe they should be used in large quantities but always within the patient's tolerance. They may be used in combination or separately.

*Web space infections* are self-evident from the tenderness and ballooning of the web between the fingers or toes. The only question of diagnostic importance is the extent of the infection and the location of the pus. Not infrequently an infection of the palmar or thenar space may extend along a lumbrical muscle to point in the web, or an infection in the web may extend along the

lumbrical muscle to involve the deeper fascial planes in the palm. Treatment consists in operative drainage through a

lumbrical muscle should be enlarged by dilating it with a hemostatic forceps.

Occasionally in soft corns between the

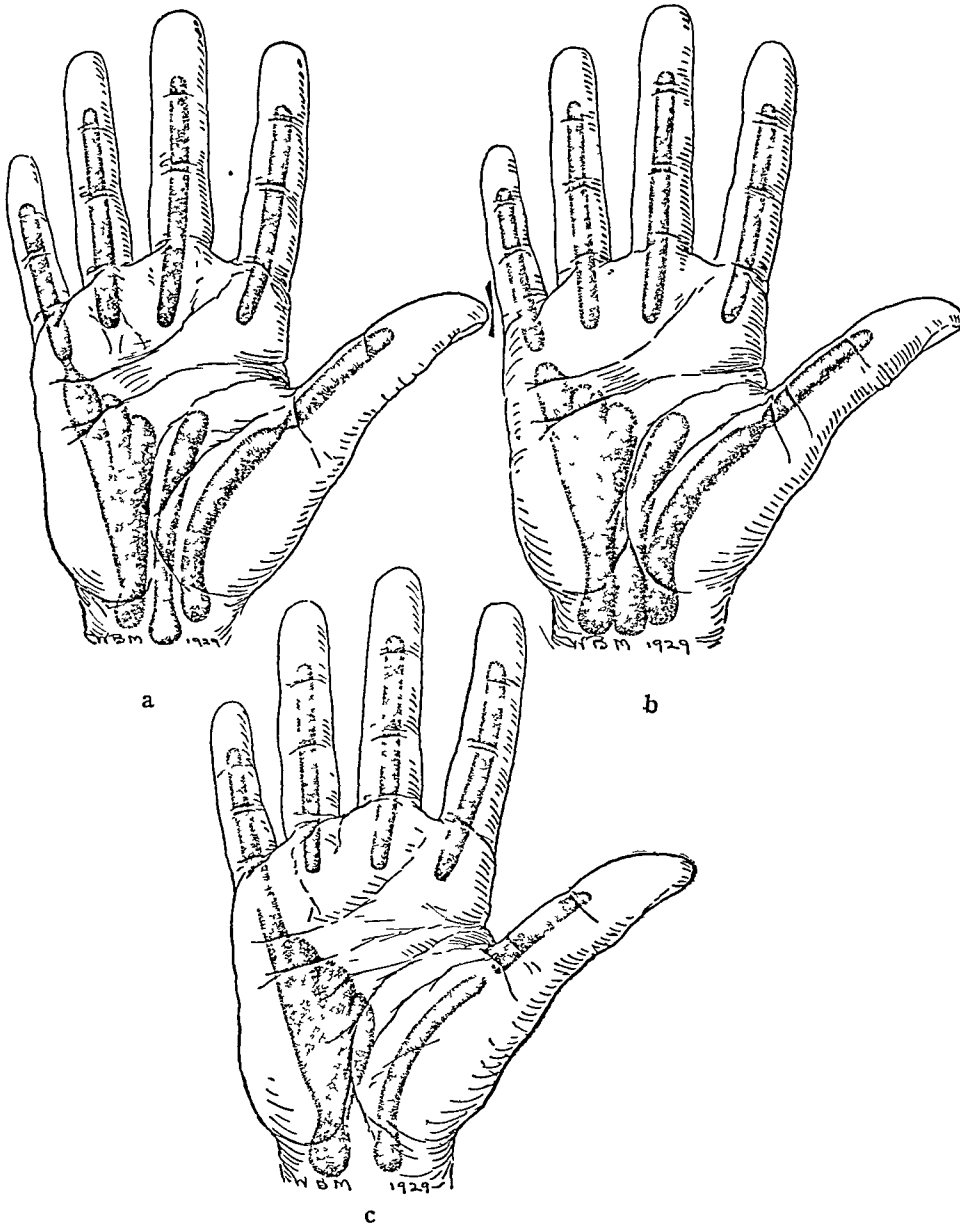


FIG. 5. Synovial sheaths of the flexor tendon. Anatomic variations are shown in *a*, *b*, and *c*. The usual arrangement is for the ulnar and radial bursa to be continuous with the sheath to the little finger and thumb respectively. The sheath to the second, third and fourth fingers stops just proximal to the metacarpophalangeal joints. The ulnar and radial bursa may communicate either directly or through an intervening bursa in the palm.

palmar incision midway between the fingers with the incision distal to the flexion creases in the palm. Such an incision might give some drainage of the palmar or thenar space, but if one of these is distended with pus the connecting channel along the

toes we have a crack or break, through which organisms gain an entrance with infection in the web. The most satisfactory treatment is drainage in the acute stage. If there is a persistent sinus this should be opened widely or excised, and the corn



should be excised when the infection is under control.

*Palmar Space and Thenar Space.* These

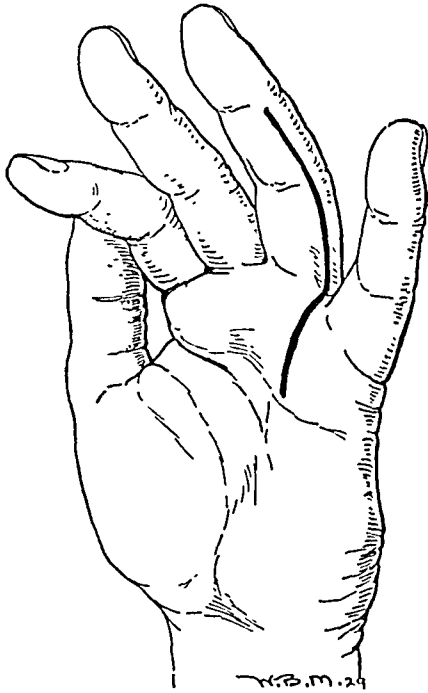


FIG. 6. Incision for drainage of an infection in the flexor tendon sheath of the fourth finger. If the sheath is opened throughout its length the finger must be kept in extension to prevent prolapse of the tendon. No drains should be inserted against the tendon.

potential roughly triangular spaces which normally may be filled with loose areolar tissue lie deep to the tendons in the palm, volar to the bones and interosseous muscles, the palmar space to the ulnar side of the third metacarpal bone, the thenar space to the radial side of this bone. Each has its apex just distal to the carpal ligament, its base about on a line joining the distal end of the middle flexion crease with the proximal end of the distal flexion crease. At times a prolongation may extend out along one or more lumbrical muscles. These spaces may be infected through a puncture wound, by lymphatic extension or by extension from the tendon sheaths or from a web space abscess. If early drainage is not instituted infection in one of these spaces may extend to the other.

The diagnosis of a thenar or palmar space abscess is made by the location of the throbbing pain and extreme tenderness on pressure along with other signs of acute inflammation. There may be in addition pronounced lymphedema of the dorsum of the hand but without induration or point tenderness.

If there is extension along a lumbrical muscle there may be evidence of a web space infection. (Fig. 3.) In the case of the palmar space abscess there is little evidence of swelling in the palm of the hand due to the rigidity of the palmar fascia, but the palm may lose some of its concavity. The thenar space abscess, on the other hand, produces a marked ballooning of the space between the thumb and index finger both on the dorsal and volar aspect. (Fig. 4.)

Treatment is by surgical drainage. The palmar space is opened by an incision in the palm, either between the third and fourth or the fourth and fifth fingers, depending on which shows the greater evidence of extension along the lumbrical canal. When there is a choice the incision between the fourth and fifth fingers should be avoided since it offers the risk of accidentally opening the ulnar bursa. This must, of course, be carefully guarded against. Occasionally it may be necessary to drain through both of these spaces. The incision is made in the distal part of the palm to avoid the vascular arches and midway between the fingers to avoid the tendon sheaths, vessels, and nerves, to the fingers. From this incision a hemostatic clamp is passed along the lumbrical canal into the collection of pus and the drainage tract enlarged by spreading the clamp and withdrawing. Here also care must be observed to avoid injury to a tendon sheath which lies to either side of the incision or a bursa which lies volar to the abscess.

The thenar space may rarely be opened in a similar manner between the index and middle finger when there is an extension into this web space. Usually, however, the thenar space abscess is approached through

an incision on the dorsum of the web between the thumb and index finger. (Fig. 4.) A clamp is inserted along the palmar sur-

either case the drainage tract is enlarged by spreading and withdrawing the clamp. Needless to say, in all cases free drainage

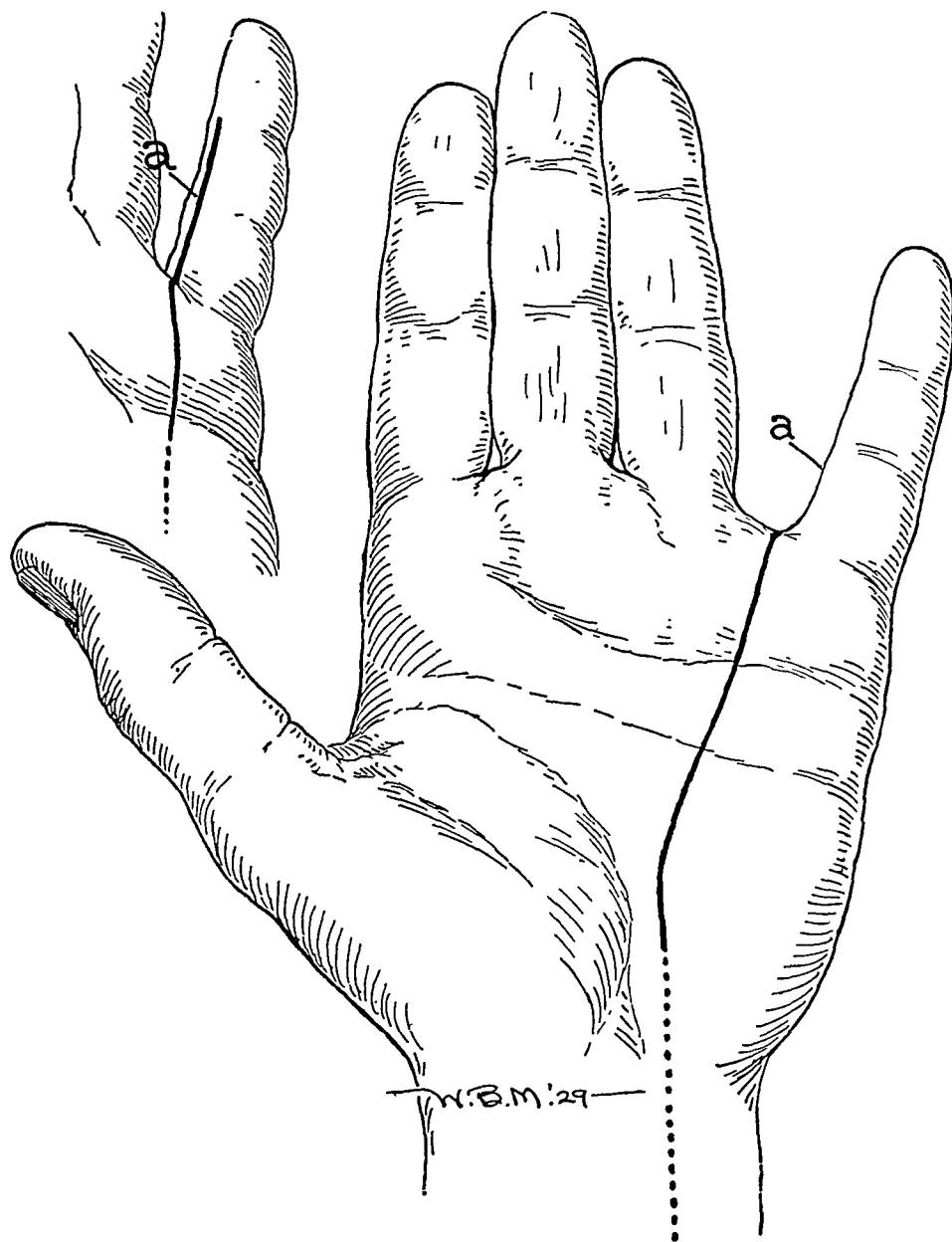


FIG. 7. Incision for drainage of the ulnar bursa and the sheath of the flexor tendon of the little finger. This incision can be carried through the annular ligament if it seems desirable in order to give free drainage of infection above the wrist. However, when this is done the wrist must be kept in extension to prevent prolapse of the tendons. This extension above the wrist is indicated by the dotted line. *a* shows the incision on the side of the little finger for drainage of the sheath.

face of the adductor pollicis muscle to enter the thenar space and is spread to provide free drainage. Occasionally the pus may dissect between the transverse and oblique bellies of the adductor pollicis muscle to reach the dorsum of the web space. In

through an adequate incision is imperative since the larger incision heals quicker with less damage to tissue than the small incision with inadequate drainage.

*Tendon Sheaths.* The tendon sheaths in the hands are of greater surgical signifi-

cance than those in the feet, due first to their more frequent involvement, and second to the wider variety of motions and

of the wrist, and rarely become infected. On the palmar surface we have the tendon sheaths to the second, third, and fourth

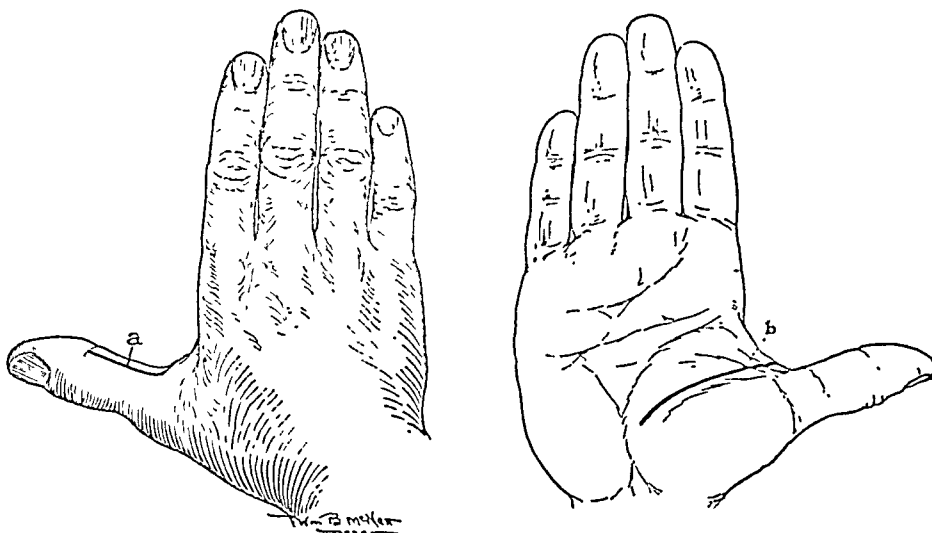


FIG. 8. Incision for drainage of an infection involving the radial bursa and sheath of the flexor pollicis longus tendon. *a* shows the incision on the side of the thumb, *b* the incision as it extends across the palm. This incision must stop at least 1 cm. short of the annular ligament in order to avoid injury to the motor branches of the median nerve, which supply some of the muscles of the thenar eminence. If the infection extends above the wrist this must be drained through appropriate incisions in the forearm.

uses to which the fingers and hand are adapted. In view of this fact the primary consideration will be given to the hand. However, one must keep in mind the sheaths in the foot as the route of extension of inflammation. This applies particularly to the sheath of the long flexor of the great toe which extends along the sole of the foot, passes behind the internal malleolus and to the dorsomedial aspect of the lower leg and may or may not be continuous over this distance. This channel of extension should be kept in mind in treating gangrene of the great toe or any infection in this region. When the toe is to be amputated in the presence of infection, suitable precautions must be taken to close off this sheath and to prevent the retraction of the contaminated cut end of the tendon. When it becomes infected, incision and drainage with the removal of hopelessly damaged and sloughing tendon is indicated.

In the hand the sheaths for the extensor tendons are short, superficial, in the region

fingers which extend from the insertion of the tendon in the distal phalanx to a point just proximal to the line of flexion of the metacarpophalangeal joints. The sheaths of the flexor tendons of the little finger and thumb, however, are usually continuous with the ulnar and radial bursae respectively. (Fig. 5.)

The radial bursa surrounds the flexor pollicis longus tendon, extends through the palm, beneath the annular ligament and into the forearm. The ulnar bursa partially surrounds the flexor tendons to the fifth, fourth, usually the third, and occasionally the second finger in the palm. It is usually, but not necessarily, connected with the tendon sheath of the fifth finger but not the others. There may be a communication between the radial and ulnar bursae in the palm, either direct or through an intervening small bursa. This anatomic arrangement permits a wider spread of infection and makes all infections in the thumb and little finger potentially more likely to

result in extensive damage to the hand than a similar infection on either the second, third or fourth finger.

Diagnosis is concerned primarily with the location of the infection since its presence is evident. Tendon sheath involvement is determined by the diffuse swelling of the finger, point tenderness along the course of the tendon sheath or bursa, absence of active motion, the involved finger being held in moderate flexion, and severe pain on passive motion, either flexion or extension. The tendons in the adjacent uninvolved sheaths may show some limitation in motion but slight motion elicits relatively little if any pain.

*Treatment.* The most important single factor in treatment is early diagnosis, with early drainage before irreparable damage has been done. The type of infection is also of great importance in determining the extent of the destruction. This to a large degree is beyond the control of the surgeon, but he can use every precaution to limit secondary infection in his drainage incisions.

Incisions for drainage should be placed on the side of the fingers and not in the midline. (Fig. 6.) Care should be taken to avoid injury to the lateral nerves and blood vessels. The finger should be kept in extension to avoid prolapse of the tendon. The incisions should be adequate to insure free drainage and no drains should be inserted so as to come in contact with the tendon.

The ulnar and radial bursae must be opened up into the palm. The incision of the ulnar bursa may be carried up through the annular ligament (Fig. 7) but this cannot be done in the case of the radial bursa (Fig. 8) since the motor branches of the median nerve to the thenar eminence will be divided and the power of opposing the thumb to the fingers will be lost. The extensions of the radial and ulnar bursae above the wrist are predominantly posterior to the tendons and these can be drained by a lateral incision just anterior to the bone on either or both sides of the forearm

just above the wrist. Care must of course be taken to avoid injury to the vessels, nerves and tendons. Occasionally there may be a pocket of pus anterior to the tendons above the annular ligament, which may be drained through an anteriorly placed incision. Needless to say that in any of these cases hopelessly damaged tendons should be removed to hasten healing. Tendon transplants can be tried later in suitable cases by one experienced in such work.

As soon as the acute infection has subsided and there is no longer danger of prolapse of the tendons, passive and later active motion should be used. As soon as healing is complete, baking, massage, active and passive motion, traction, etc., should be instituted and persisted in for an indefinite period of time or until full function is restored. It should be emphasized that these patients should not be treated except by a person of wide experience in infections of the hand and then only if he has available every facility for the restoration of function. Even under the best of conditions the results may be poor.

*Deep forearm infections* usually result from an extension of an infection in the radial or ulnar bursae or rarely the palmar or thenar space. The pus is located anterior to the bones, interosseous septum and pronator quadratus muscle, and beneath the tendons. It may dissect up the forearm, reach the loose tissue about the median nerve or the ulnar nerve and artery and follow a course along these either up or down the arm.

A deep forearm abscess is best drained by a lateral incision passing just anterior to the ulna a few centimeters above the styloid process. An incision can then be made with greater safety on the radial side if through and through drainage is considered advisable, by passing a hemostat through and incising on the point. Care must be taken to avoid injury to the nerves and arteries, the incisions being posterior to these structures.

*Pyarthrosis* is treated as such a condition elsewhere by early free drainage, avoidance of drains into the joint, maintenance of mobility of the joints if possible, and traction to minimize damage to the articular surface.

*Osteomyelitis* is also treated on the same general principles as apply elsewhere; that is, by early free drainage, with the minimal trauma, general measures to increase the resistance of the patient, transfusions, antitoxins when available, and chemotherapy with sulfanilamide or related drug when indicated. After drainage is established and the acute condition is over it is best to await separation of the sequestrum. After this has separated and is no longer needed to maintain the shape of the part it should be removed, and the wound allowed to heal.

In the hand or foot osteomyelitis and pyarthrosis are frequently associated and

are likely to result in prolonged illness and serious permanent disability. In the small joints there may be loss of mobility and the parts should be kept in the best position for function. At times when the stiff, deformed digit is more of a handicap than an asset it may be wise to remove it. If the small bones and associated joints of the wrist or ankle are involved, the condition is difficult to cure, follows a prolonged course, should have free drainage, may require removal of many or all the small bones or eventual resection of the joint. Care should be taken to see that the joint is kept in the best position for function. Such infections demand the most skilled care, diagnosis should be made or suspected at the earliest possible time and the case placed in the hands of one experienced in handling such conditions. Space does not permit a full consideration here.



# ACUTE OSTEOMYELITIS

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DETROIT, MICHIGAN

**A**CUTE hematogenous osteomyelitis is essentially a disease of the growing period, occurring most frequently in children between the ages of 3 and 16. Because of its high mortality rate and frequent crippling aftermath, acute osteomyelitis in children is one of the most serious surgical conditions encountered and one in which early diagnosis and treatment are of paramount importance. Much has been written on the subject and most writers are unanimous in their conception of the etiology, pathogenesis and pathology of the disease. In the past few years, however, because careful analyses of a large series of cases from many clinics have revealed an alarmingly high mortality rate, different methods of treatment have been advocated. As a result of this, a certain amount of confusion exists today in the minds of the medical profession in regard to the most efficacious method of handling acute hematogenous osteomyelitis. Naturally, as there are a great many variables present, it is impossible to generalize about the treatment. However, a few uncontradictable facts have been assimilated which should help in the management of this condition and appreciably reduce the mortality rate.

*Etiology.* The causative organisms are predominantly the staphylococcus and the streptococcus and much less frequently the pneumococcus, colon and typhoid bacilli. Statistics from a large number of clinics show that the staphylococcus is the invading organism in from 69 to 90 per cent of the cases. In a series of thirty cases studied at the Henry Ford Hospital, twenty-six, or 86 per cent, were due to the staphylococcus. According to Green,<sup>1</sup> in osteomyelitis seen in infants under 2 years of age the streptococcus is encountered more frequently than the staphylococcus in a ratio of about 2:1. The primary source of infection is often

difficult to determine, although in many instances a history may be obtained of a preceding skin infection such as a boil, wound or abrasion. In other cases the bone lesion may occur as a sequel to middle ear infection, acute tonsillitis or abscessed teeth. As a result of bacteremia or septicemia, the organisms are conveyed to the bone, usually to the metaphysis of a long bone. The flat bones, such as the ilium and skull, and the short bones of the hands and feet are less frequently involved.

*Pathology.* The pathologic concept that is almost universally accepted is an initial infection in the metaphysis of a bone conveyed there by the blood stream. It has been suggested by some writers<sup>2,3</sup> that the term "acute hematogenous metaphysitis" more accurately describes the pathology. There are several factors that probably account for the localization of the bone lesion in the metaphysis rather than in the medulla. Experimental work by Teruo Hobo,<sup>4</sup> Robertson,<sup>5</sup> and others has demonstrated that there is a lessened power of phagocytosis or an absence of it at the metaphysis. In addition, it has been shown that there is a large venous bay in the metaphysis which permits marked slowing of the blood stream. The organisms produce local bone necrosis and the abscess so formed spreads rapidly in the line of least resistance—usually toward the periosteum. Pus then usually spreads under the periosteum, stripping it from the bone and often extends the entire length of the shaft. Relief of tension of the abscess is obtained either by spontaneous rupture of the periosteum or by surgical drainage. That portion of the shaft that has been deprived of its circulation dies and the dead bone is gradually separated from the living bone, forming a sequestrum. Under the raised periosteum, new bone known as the involucrum is laid down. The sequestrum

is either extruded spontaneously or removed surgically.

Robertson<sup>5</sup> has emphasized the fact that because of the exotoxin produced by the staphylococcus, osteomyelitis caused by this organism is a much more serious condition than that caused by the streptococcus. The toxin not only produces bone necrosis but causes serious changes in the vascular system. He points out that if the individual possesses an inadequate amount of natural antitoxin, the disease is likely to prove overwhelming unless adequate combative measures are used.

*Symptoms.* The first symptoms complained of are usually pain and stiffness in the region of a joint. A history is frequently given of a recent injury to the involved area. Within twenty-four hours the pain becomes very severe and the temperature is elevated, often to 103°F. and higher. There is an accompanying leucocytosis ranging from 10,000 to 25,000. These children are frequently extremely toxic and exhibit all the signs of an acute blood stream infection. Careful local examination in the early stages will reveal the point of maximum tenderness to be in the neighborhood of the epiphysis and not over the joint. The joint can be moved without undue pain if motion is carried out carefully. Later when the periosteum and soft tissues have become involved there is, in addition, swelling, redness, edema and often fluctuation.

The blood culture is frequently positive for staphylococcus or streptococcus. Robertson has stated that if cultures are taken at frequent intervals, blood stream infection can be demonstrated in every case of acute hematogenous osteomyelitis.

Symptoms of acute osteomyelitis in the adult are usually quite different from those in the growing child. The onset of symptoms is much more gradual and the patient is rarely as acutely ill. The localization of the lesion, instead of in the metaphysis, is usually in the shaft of a long bone and frequently in the mid-portion. Symptoms of pain and tenderness on pressure may be present for days or even weeks before signs

of a general reaction supervene. X-ray evidence of bone infection is late in appearing and a diagnosis of osteomyelitis is extremely difficult to make unless one has in mind the possibility of such a condition. Temperature elevation, leucocytosis and a moderate degree of toxicity usually supervene after a week or two of milder symptoms. Often, coincident with the appearance of these symptoms, there will be roentgenologic evidence of bone involvement.

*Treatment.* Until recent years the opinion of medical men and surgeons was almost unanimous in regarding acute osteomyelitis as an emergency and early operation was the universal method of treatment. The type of operation varied according to the merits of the individual case and the preference of the surgeon. The procedures of choice were: incision of the periosteum, multiple drill holes into the metaphysis or guttering of this area. The operation of diaphysectomy has long been discarded as being unnecessary and too mutilating.

Because of a mortality rate that has remained persistently high regardless of or because of too early surgery, more conservative treatment is now being advocated by many surgeons. It is argued that the bone focus represents merely a local manifestation of a general infection and that treatment should be directed toward raising the patient's resistance. The abscess is allowed to rupture spontaneously or incision and drainage of the soft tissue abscess are done when the child's condition warrants such a procedure. Wilson and McKeever<sup>6</sup> report a mortality rate of 25 per cent in a group of twenty-four patients treated by early operation and only 9.7 per cent in a comparable group of thirty-one patients in whom drainage was done from the seventh to the twenty-eighth day of the illness. Crossan,<sup>7</sup> on analyzing 121 cases, found a mortality rate of 35 per cent with operation in the first week, in contrast to 3 per cent in the second week and 15 per cent in the third. Pyrah and Pain<sup>8</sup> made similar observations on a series of some 260 cases studied and stated: "Incision into an

area in which such unlocalized, perhaps rapidly spreading inflammation is present, will on the one hand give exit to toxic material and to accumulating inflammatory debris, but on the other hand it must inevitably open up tissues which can allow of the rapid absorption of toxic material by veins and by lymphatics into the general circulation."

Each method of treatment undoubtedly has merit, but in dealing with a condition presenting as many variations as acute osteomyelitis, it is impossible to generalize about the manner of attack. The type of treatment indicated varies with many factors, including the age of the patient, duration of the lesion and degree of toxicity present. Early operative treatment in certain cases may be the means whereby much bone destruction and future disability is prevented whereas in other cases early operation is definitely contraindicated and constitutional measures are far more important. The method of treatment that appears to be best indicated will be discussed according to the age levels.

1. *Acute Osteomyelitis in Children under Two Years of Age.* Green<sup>1</sup> and Ober<sup>9</sup> have recently demonstrated that acute osteomyelitis in infants is a different problem from the same disease in children over 2 years of age. The predominating organism encountered in the former group is the streptococcus. The abscess extends rapidly from the metaphysis to the cortex and perforates the thin periosteum, forming a localized abscess in the soft tissues. These children are usually very toxic and measures to combat the constitutional disturbance are of primary importance. Dehydration, which is almost constantly present, is controlled with intravenous fluids. Transfusion of small amounts of blood, given daily or every other day, is undoubtedly beneficial. Sulfanilamide is indicated in this group since in the majority of cases the streptococcus is the causative organism.

As soon as the child's condition warrants it, the abscess is opened under anesthesia, the pus is evacuated and a vaseline pack is

inserted loosely in the wound. No attempt is made to open the bone. Dry dressings are placed over the wound and a plaster of Paris cast is applied to the extremity. The cast may be windowed and dressings done at intervals of from one to two weeks. The wound usually heals in from two to three months and sequestrum formation is extremely rare. After a period of from one to two years there is usually complete restoration of the contour of the bone.

Green reports that since the adoption of this type of treatment in infants the mortality rate has been reduced from 21 per cent to 5 per cent.

2. *Acute Osteomyelitis in Children over Two Years of Age.* Treatment of acute osteomyelitis in this group varies with the condition of the child when first seen. Generally speaking, if the child is quite toxic, dehydrated and has a temperature elevation of 103 degrees or over, operation should be delayed and supportive measures undertaken. The mortality rate in this group with too early surgery and disregard of the child's general condition has been appallingly high.

Dehydration should be combated with large quantities of fluid by mouth or by the intravenous route. Small blood transfusions daily or every other day are indicated. If the blood culture is positive for streptococcus, sulfanilamide may be used. If, as is true in about 80 per cent of this group, the staphylococcus is the causative organism, staphylococcus antitoxin will often aid in decreasing the toxicity of the child and perhaps prevent metastases. This preparation has not been used extensively enough yet to warrant any definite conclusion, but indications are that it will prove an important adjunct to the treatment of staphylococcal osteomyelitis. The antitoxin is given intramuscularly in doses of 30,000 to 150,000 units.

When the child's general condition warrants it, which may be in from a few days to two weeks after the onset, the abscess may be drained. Surgery even at this time should be minimal and incision of the soft tissues or of the periosteum is usually all



that is necessary. The wound is gently packed with vaseline gauze and the extremity is immobilized in a splint or encased in a plaster of Paris cast. The wound may be dressed at intervals of from one to two weeks and at a later date when sequestration is complete, a second operation may be performed for removal of dead bone.

If the child is seen a day or so after the onset of symptoms, is not toxic and the temperature range is below 103°F., early operation, in the writer's opinion, is the method of choice. The operation is done preferably with the use of a tourniquet and the bone is approached by the most accessible route, avoiding any undue trauma to the soft tissues. If pus is not encountered under the periosteum, drill holes are made through the cortex in the direction of the metaphysis, with care not to damage the epiphysis or enter the medulla. Often several such drill holes are necessary before pus can be seen escaping under pressure. A small window of bone is then removed with a thin sharp osteotome, exposing the abscess cavity, which should not be curetted. Vaseline gauze is packed loosely in the wound and the extremity is immobilized in a splint or a plaster of Paris cast.

Early drainage of the bone focus is undoubtedly an ideal procedure if the child's physical condition warrants it. Unfortunately, in the majority of cases the child is seen late, at which time the general condition precludes early surgery. In ideal cases, however, by early operation, subperiosteal spread of the abscess is prevented, toxic absorption and destruction is minimized, metastases and, in many cases, sequestrum formation is prevented, or if present, is minimal.

3. *Acute Osteomyelitis in Adults.* Acute osteomyelitis in the adult is seen quite rarely and, as mentioned above, the clinical picture is quite different from that seen in children. The process is slower and roentgenograms may not show bone changes for from two to four weeks from the time of onset. The lesion is usually in the shaft and

is rarely in the metaphysis. As soon as the diagnosis has been established, the bone should be exposed through the most accessible route over the involved area. Drill holes should be made through the cortex to determine accurately the location of the abscess and a window is then lifted from the bone to permit adequate drainage. The wound is packed with vaseline gauze and the extremity adequately immobilized. Healing is usually slow, often taking from three to six months, but sequestrum formation is rare and recurrence is seen less frequently than with osteomyelitis in children.

#### SUMMARY

Acute osteomyelitis is a serious surgical condition that, because of its high mortality rate, warrants the most careful consideration before operation is performed. Treatment, to a large extent, must be individualized and factors such as the patient's age and general condition, the degree of toxicity, and duration of the lesion are important in determining when surgical drainage may be most advantageously done. If proper consideration is given to these factors and each case treated according to its individual merits, the mortality rate will be appreciably reduced.

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# COMPOUND FRACTURES

WITH SPECIAL REFERENCE TO THE LOWER EXTREMITY

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ALTHOUGH accurate data are lacking otherwise, the results in death and disability after compound fractures are shown very well by the statistics of the war of 1914 to 1918. In compound fractures of the thigh and leg particularly, the number of war wounded dead or permanently disabled, five years after our military experience, was shown by the Surgeon-General's report to be far larger than it should have been. It is sometimes claimed that peacetime injuries are less severe and results obtained in civil practice much better. A careful study of the patients in almost any hospital will show that they not only do no better but often do worse than those described in the Surgeon-General's Report.

Following my own military experience in 1917-1919 I called attention<sup>1-5</sup> to the necessity for better primary reduction and immobilization in these compound bone and joint injuries. Unfortunately, the atmosphere surrounding treatment for compound fractures was clouded during and after the war period by attempts to apply various so-called "war lessons" to these patients. Supposed "improvements" included constant irrigation of compound fracture wounds, early mobilization of joints in the vicinity of fractures, modifications of standard splints, and other details of technique, all tending to render less efficient splint methods suggested by Sir Robert Jones and others who had become expert in dealing with war injuries and in preventing disability and deformity.

Even the teachings of Lister with regard to compound fracture wounds were forgotten in the supposed discoveries of the war period. Actually, the results of treatment in compound fractures were not so good during the Great War as those

demonstrated to us by Lister in his first cases treated with carbolic acid fifty years before. Moreover, the fundamentals of fracture treatment—primary reduction and immobilization in correct position—were forgotten in most cases, in attempts to cure septic wounds by frequent irrigations, to maintain motion by joint movements, to refine transportation splints, and in experiments with other details of treatment.

At the present time we are still in confusion as to the handling of compound fractures. There have been so many attempts to discover a chemical cure for septic wounds, to modify splints and to provide special gadgets to control these patients, that the fundamentals are neglected or all but forgotten. Besides, the old teaching that every patient is an individual problem to be solved only by the particular surgeon who is attending him at the moment, is one that should have been exploded long ago. The fact is, that the same principles and to a very large extent the same details of treatment may be applied in every case of compound fracture if certain important facts are kept in mind.

This is a point to which this writer has called attention for the past twenty years. Numerous papers<sup>6-12</sup> have pointed out that primary reduction and immobilization in correct position are the two things necessary in all cases of fracture, simple or compound. Also, now that we know that frequent dressing of the wound is unnecessary, suitable simple splints and casts are sufficient to attain these objects in every fracture case.

These points in treatment, including infrequent dressings, have been accepted by hundreds of surgeons all over the world. There is a large mass of literature which shows the tendency in that direction. The

recent publications of Dr. J. Trueta, formerly of Barcelona, indicate how successful the application of these simple

shall submit a description in detail of our own exact technique in dealing with compound fracture cases. These methods apply

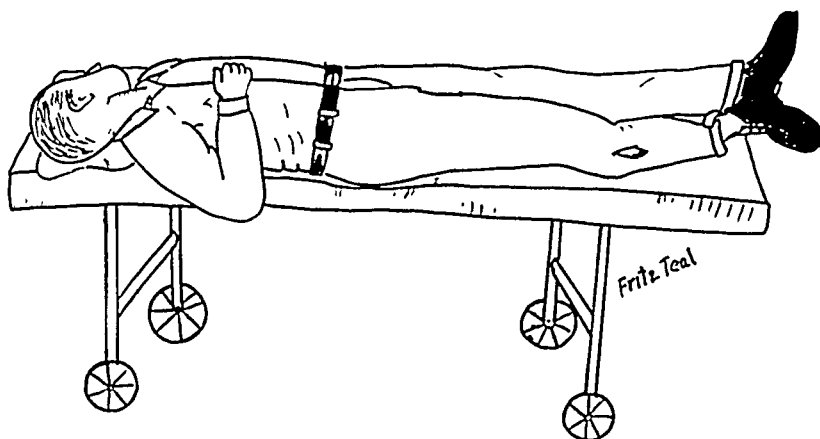


FIG. 1. The patient arrives at the receiving room from the ambulance—usually without a splint.

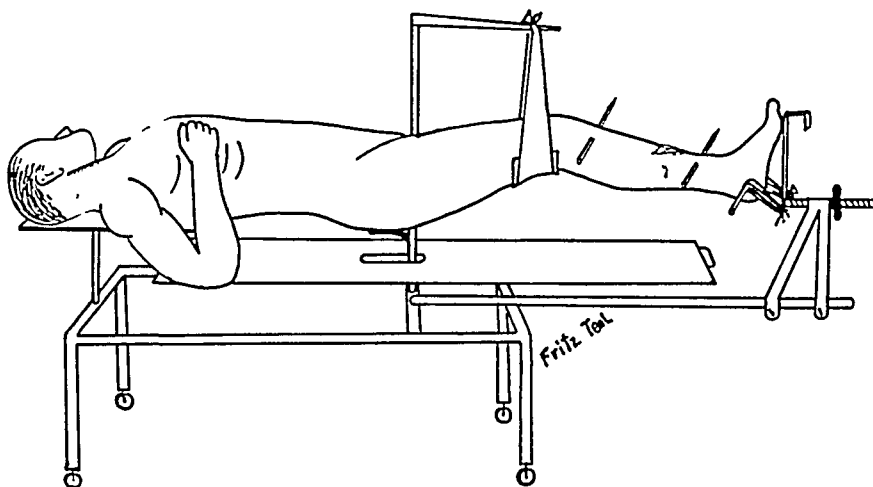


FIG. 2. The limb is brought into full length and fragments into correct relationship by traction by a pin through the os calcis. Fixation pins inserted below and above fracture when necessary.

rules may be even in gunshot fractures, as they were handled under war conditions in Spain. Dr. Trueta has published a report of more than 1,000 gunshot fractures, including the femur and leg, with only six deaths in the entire series. These were all treated by the plan of primary reduction, immobilization in plaster of Paris casts, drainage of the wounds by means of vaseline or other simple packs and infrequent dressing.

In response to many recent letters and for the first time in several years, I

to all cases, no matter in what part of the body the compound bone injury is situated, and in early or late treatment. New drawings or diagrams are submitted to clear up some of the points in regard to which numerous inquiries have also been received.

First, the compound fracture patient, whether a recent case or one brought in for treatment following prolonged infection, drainage, deformity or disability, is placed upon the fracture table. With suitable preparation in the way of sedatives, fluids,

serums, etc., immediate adjustment of the patient and his extremities is made on the operating table. This is done in such a way

portions of the extremity. In more than 90 per cent of all cases, early or late, this can be accomplished with very little

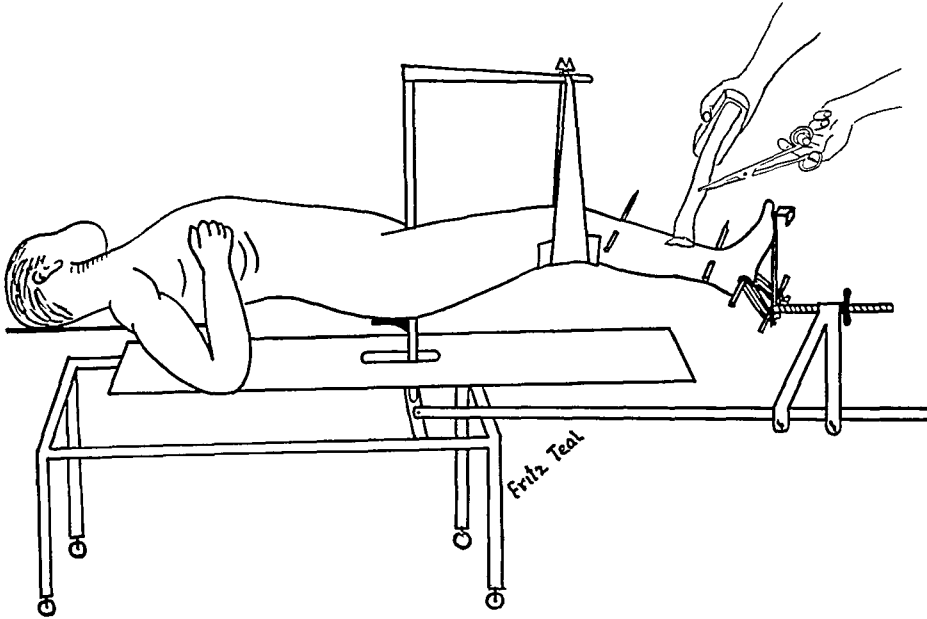


FIG. 3. Debridement or drainage operation is done (early or late cases) and the wound packed lightly to the bottom with vaseline gauze. Dry cotton gauze pads are bandaged on.

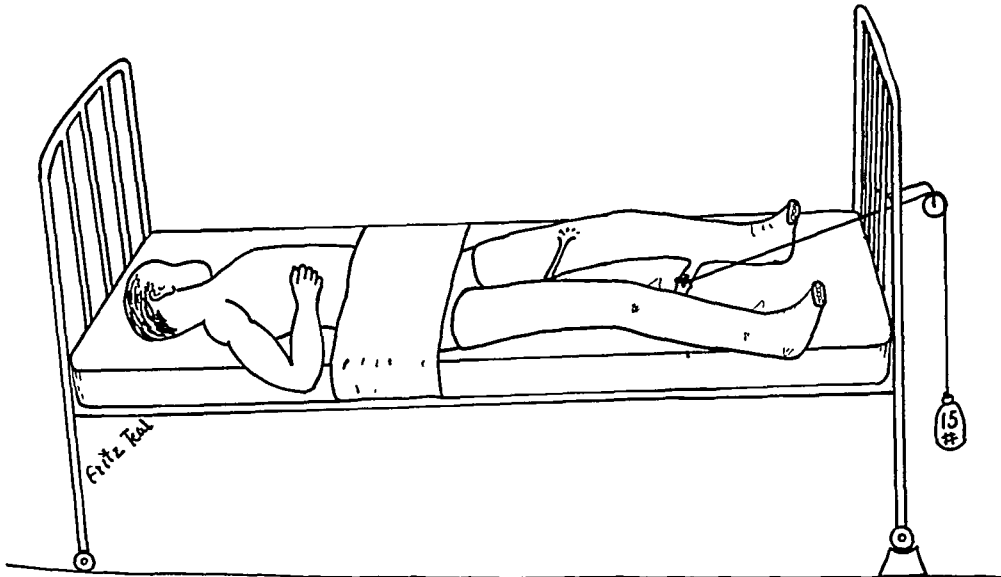


FIG. 4. In double spica cast the patient is put to bed with foot of bed elevated slightly and 10 to 15 pounds of weight attached to the cross bar. Patient is to be turned on the face three or four times each twenty-four hours. No windows in the cast or dressings until healing is well established.

that the injured limb is brought into full length, correct anatomic relationship of all the parts, and proper rotation of the distal

difficulty. With *adequate traction* very little manipulation will be required to put all the injured parts in correct position.

Emergency length and position having been secured, plans are made at once for making this position permanent. One must provide for fixed traction in the subsequent splint or cast. When necessary, pins are passed through the limb distal to the fracture, and then proximal to the fracture. The original pull should often be made upon a pin through the heel or one of the metatarsal or metacarpal bones. These pins must be moderately heavy and must be such as will remain in position without becoming loose or causing irritation.

If ice tongs or wires are used and especially if weight and pulley traction are applied to these after the operation, loss of position, with irritation about the pins or wires is almost certain to occur. In our cases, subsequent permanent fixed traction is obtained by the application of the plaster of Paris cast to include the limb and the pins. A rule you will remember is that skeletal fixation devices, if allowed to wobble at the ends or at the portions outside the limb, will certainly become loose in the bone and cause irritation, necrosis and infection in the bone and at the points of entrance and exit in the skin. If the patient, the limb, and the skeletal fixation devices are all immobilized in the cast, no such complications will occur.

After the wound at the point of fracture has been provided with suitable drainage, either with a vaseline pack or in some other way (debridement, of course, having been done as a preliminary) the patient is placed in the permanent plaster of Paris cast. For almost twenty years with us, this has been a double plaster of Paris leg cast or spica.

Following his visit to us in 1927, Dr. Roger Anderson devised an apparatus for this purpose and called the method "well leg traction." This is not a good term because fixation of the well leg contributes very little to the traction. This traction, by our plan, is really intrinsic in the cast on the injured limb, but the double cast does provide better control by means of a cross bar for the injured limb and the patient.

My own original suggestion regarding this method came from the double abduction splints of Hugh Owen Thomas and Dr. Bradford of Boston, who had used them for many years.

The fixation pins, having been caught in the plaster of Paris cast and both limbs having been included in the plaster with a cross bar between, the traction on the foot at the lower end of the table may be released. The illustrations show that no loss of length or position can occur. The feet are then included in the cast. This makes the patient more comfortable and adds to the immobilization of all the injured parts.

After the patient is put to bed a weight and pulley traction on the cross bar between the limbs adds further to his comfort, because it prevents spasm about the thighs and hips and helps relaxation.

No windows are made in the cast and no dressings are necessary. The injured limb and the wound should be let alone until healing has progressed to the point where both the fracture and the patient are safe from the complications that might otherwise occur.

If the patient does develop pain, interference with circulation, or swelling in the limb, rise of temperature or increased white cell count, these must have consideration as in any other surgical case. However, to tear off splints or casts or to start antiseptic irrigation of an already properly drained compound fracture wound is entirely wrong. The only indications, as a rule, are to release constriction if necessary, or to provide drainage at the original wound or elsewhere. Then let wound and patient alone for gradual recession of symptoms—which will always occur.

The after-care of our patients is actually as simple as that. After some weeks or months they are taken to the operating room, an anesthetic is administered, pins are taken out, the cast is removed and such a revision of position is done and such a dressing applied as may be necessary for a satisfactory final result.

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RHAZES . . . was perhaps one of the first men to use sutures of animal gut for the repair of abdominal wounds. It may have been his early musical training which suggested the diversion of harp-strings to this end.

The brief excerpts in this issue were taken from "The Story of Surgery" by Harvey Graham (Doubleday-Doran).

## BOOK REVIEWS

**THE SURGERY OF PAIN.** By René Leriche, M.D., F.R.C.S. Translated and edited by Archibald Young, Regius Professor of Surgery, University of Glasgow. Baltimore, 1939. Williams & Wilkins. Price \$6.50.

This book is different. It will be read and re-read and much pondered over. Readers may disagree with the author in minor matters, but the average surgeon will have at least some of his viewpoints changed as he reads.

Leriche is probably the one man responsible for the pioneer work in the surgical alleviation of pain. He began during the World War when he was particularly interested in victims suffering from causalgia. His experimental and surgical work at Strasbourg and Lyons carried him into research on the neural and vasomotor causes of pain and into procedures for its relief.

The present volume represents lectures given in connection with the chair of medicine at the Collège de France. It has been brilliantly translated by Archibald Young, who has rendered the spirit as well as the letter of the French into fine English prose. In his preface, Professor Leriche says that his lectures "are devoted to the study of pain from the point of view of a surgeon. . . . The author's aim has been to investigate the problem of real, or *living* pain, as seen through the ever changing mirror of the clinic, and removed as far as possible from the cold abstractions of book doctrine."

As we said in the beginning, this book is different. We hope that it will find its way into the hands of many, many surgeons.

**MENSTRUAL DISORDERS: PATHOLOGY, DIAGNOSIS AND TREATMENT.** By C. Frederic Fluhmann, M.D., Philadelphia, 1939. W. B. Saunders.

The general practitioner probably meets with as many women suffering from menstrual upsets as does the gynecologist. He must know, as must the latter, of the great changes in concepts of the physiology, pathology and treatment of these disorders which have taken place

in recent times. Therefore the publication of this concise, to the point book (329 pages) is particularly well timed.

Much space and emphasis are given to the important field of the endocrines, but the subject as a whole has been viewed as a general problem. The author gives detailed treatments directed to basic causes where these are known, and also suggests methods for symptomatic relief.

Gynecologists will find the work interesting, but we hope that this book will be read by the multitudes of practitioners of general medicine who can gain definite knowledge of diagnosis and form intelligent bases for treatment. There is no longer any excuse for prescribing the first hormone or combination of hormones that comes to mind.

**THE CLINICAL AND EXPERIMENTAL USE OF SULFANILAMIDE, SULFAPYRIDINE AND ALLIED COMPOUNDS.** By Perrin H. Long, M.D. and Eleanor A. Bliss, Sc.D. New York, 1939. Macmillan. Price \$3.50.

Six years have passed since Foerster first reported upon the use of *prontosil*. In the intervening time we have witnessed the conquest of streptococcal, meningococcal, gonococcal, pneumococcal, and many other types of infections by means of chemotherapy. The volume of reports upon the various aspects of the new bacterial chemotherapy is enormous, and because of this the summary presented in this new book is especially needed. Although much has been learned in the control of bacterial infections, it is apparent that much remains to be done.

The contents of the book include a historical sketch of sulfanilamide therapy, a study of the chemotherapy of experimental bacterial infections, experimental toxicity, and analysis of the comparative pharmacology of sulfanilamide and its allied compounds. The modes of action of sulfanilamide and its derivatives, the clinical use of this drug and of sulfapyridine, etc., receive detailed discussion. The wide applicability of the drugs makes the subject of almost universal interest in medicine.

A TEXTBOOK OF BACTERIOLOGY. By Hans Zinsser, M.D., and Stanhope Bayne-Jones, M.D. Eighth Edition. New York, 1939. D. Appleton-Century. Price \$8.00.

The first edition of this standard work appeared in 1910. Now, in 1939, the eighth edition appears. What can a reviewer write that has not already been written concerning this perfect Textbook? The authors, men of international reputation, have kept the work abreast of the scientific times. No one can criticise the text-matter. This is the subject of bacteriology brought into complete and useful form.

A TEXTBOOK OF SURGERY. By American Authors. Edited by Frederick Christopher, M.D., F.A.C.S. Second Edition. Philadelphia, 1939. W. B. Saunders.

The editor, in the preface, states, "The dominant plan of this textbook is to give the student a concise presentation of surgery which is characterized by the maximum authority." In 1695 pages the contributors (over 110 in number) have presented only tested and accepted present day principles in surgery, omitting all debatable and incompletely tried methods. The entire range of the surgical field has been covered. There are 1381 illustrations, important references listed at the end of each chapter, and an exhaustive index.

ROYAL NORTHERN OPERATIVE SURGERY. By the Surgical Staff of the Royal Northern Hospital. London, 1939. H. K. Lewis & Co. Price £2.2.0.

Eleven surgeons of the Royal Northern Hospital have written a book which is designed to represent as far as possible the practice which is followed in the Royal Northern Group of Hospitals. The special subjects have been omitted, and to make the work as practical as possible, classical procedures and those that have passed out of common use have not been described. As a rule, one well-tried way of performing any given operation has been presented. The aim has been to produce a live surgery to help and refresh the practicing surgeon. In accordance with this aim, the book is concise, well written, amply illustrated.

DISEASES OF THE NOSE AND THROAT. By Charles J. Imperatori, M.D. and Herman J. Burman, M.D. Second Edition. Philadelphia, 1939. J. B. Lippincott.

The relationship of allergy to rhinology in general and to polyposis in particular has been stressed in the new edition of this work to conform to the present trend. The authors have added to the section on the nose a discussion of dermoid cysts, telangiectasia, injuries, the cytology of nasal secretions, and fractures of the nasal sinuses. They have rewritten the chapter on orbital infections as a complication of sinusitis.

The work shows careful writing. The illustrations, 480 in number, are excellent.

PERIPHERAL VASCULAR DISEASES: DIAGNOSIS AND TREATMENT. By William S. Collens, M.D. and Nathan D. Wilensky, M.D. Springfield, 1939. Charles C. Thomas. Price \$4.50.

Within recent years much scientific interest and new research has been devoted to the peripheral vascular diseases. Dr. Collens and Dr. Wilensky therefore present a concise authoritative résumé of the facts on peripheral circulation, embodying the surveys and extensive experimental work done, as well as detailing the clinical literature and supplying practical information on the diagnosis and treatment.

PYE'S SURGICAL HANDICRAFT. Edited by Hamilton Bailey, F.R.C.S. Eleventh Edition. Baltimore, 1939. Williams & Wilkins. Price \$6.00.

It is fifty-four years since Pye's Surgical Handicraft first appeared. Surgical procedures and technique, especially minor surgery, have changed greatly with the passing of time. In this the 11th edition, Hamilton Bailey, keeping to the original purposes and aims of the author, has made the work modern in every way. The title page reads, "A Manual of Surgical Manipulation, Minor Surgery, and Other Matters Connected with the Work of House Surgeons and of Surgical Dressers." This is as good a description of what the book is about as one can wish.



**CHIRURGIE UND RHEUMATISCHE KRANKHEITEN.** By A. Fonio, M.D. Leipzig, 1939. Theodor Steinkopff.

This monograph gives an excellent survey on the theories, the anatomy, and the clinical pictures of the diseases of the joints except for those caused by infections such as tuberculosis, lues, gonorrhoea, purulent conditions and by neuropathology like tabes. The diseases of the joints with a syndrome analogous to chronic rheumatism but due to a different cause—Still's disease and tuberculous rheumatism (Grocco-Poncet)—have been described in detail. About ninety of the 220 pages are devoted to description of joint diseases of non-rheumatic origin. This includes the various types of arthrosis deformans, joint conditions in cretinism, hemophilia, juvenile osteochondritis and osteochondropathies, and metabolic diseases of the joints. The author's style and the few illustrations are good.

The origin of the title of the book is dubious, as there is practically nothing in the work relating to surgery or therapy of any kind.

**OBSTETRICAL PRACTICE.** By Alfred C. Beck, M.D. Second Edition. Baltimore, 1939. Williams & Wilkins. Price \$7.00.

When Beck's book, presenting the essentials of obstetric practice to undergraduates and practitioners, came out four years ago, it was an instantaneous success. Within a year's time the edition was exhausted and a large second printing was necessary. Medical students, teachers and physicians found this text to their liking since it not only adhered to the strictly scientific throughout, but was readable as well. It made its points in no uncertain terms.

The new edition maintains these excellencies. The arrangement of content matter is logical. The section describing the mechanism of normal birth and abnormal deliveries is unique and original. Only a great teacher could have given us this presentation. Over 1100 drawings illuminate the text, and each one is necessary to make the point in question.

The extensive new work in the field of physiology has been included. Chapters on toxemia and abortion have been largely rewritten. The discussion of some of the complications of pregnancy is revised, and a chapter

on retained and adherent placenta has been added.

The book as a whole is 858 pages long and is well indexed. It is undoubtedly one of the best texts on obstetrics now available in this country.

**AN ATLAS OF SURGICAL OPERATIONS.** By Elliott C. Cutler, M.D., and Robert Zollinger, M.D. New York, 1939. Macmillan. Price \$8.00.

We do not know just where to bestow the greater praise: to Drs. Cutler and Zollinger for the plan and the text or to Miss Mildred B. Codding for the illustrations. All three have done their work admirably and have created one of the great classics of surgery.

The book itself is a large sized volume, 8½ by 12½ inches, which opens flat to show on each left hand page the description of a surgical procedure and on the facing right hand page the step by step technique illustrated masterfully. The broad surgical field is covered, so that the surgeon will find here every necessary detail. The surgical intern, resident or staff member may profitably consult this instructive work, since it is remarkably valuable and deserves the wide distribution it will undoubtedly receive.

**THE STORY OF SURGERY.** By Harvey Graham. New York, 1939. Doubleday, Doran. Price \$3.75.

This book, on the literary side of medicine, can be of interest to layman and physician—surgeons especially will find it fascinating. Oliver St. John Gogarty tells us in his introduction that it is "the best book on surgery I have ever read." We feel sure others will echo this.

In over 400 pages, the entire history of surgery is surveyed from its earliest phases to the surgery of "today and tomorrow." Most of the facts are probably familiar to the well informed, but the author presents them in intriguing fashion. Once started, the book is difficult to put down.

**THE PHYSIOLOGY AND PHARMACOLOGY OF THE PITUITARY BODY.** Volume II. By H. B. Van Dyke. Chicago, 1939. University of Chicago Press. Price \$4.50.

Reports on the functions and interrelationships of the pituitary run up into the hundreds

each year, and periodic summaries of the status of endocrine physiology are therefore not only desirable but necessary. Since 1934 research has been particularly active, advances have been noteworthy and confusion rife. Dr. Van Dyke has therefore rendered signal service to biology and medicine in taking the massive literature, digesting it and reporting the results. This volume represents the gist of the experimental and clinical literature on the pituitary which has appeared since 1935. We can think of no volume which matches it. To endocrinologists it probably represents required reading.

**THE ORGANISM.** By Kurt Goldstein, M.D. New York, 1939. American Book Company. Price \$4.00.

This work, the result of years of observations, especially of soldiers with brain injuries, was made possible by the hospitality the author found in the Netherlands and the support of Dutch and American foundations. It is a holistic approach to biology derived from pathologic data in man. The volume is primarily addressed to the student of the biological sciences who is familiar with the technicalities of contemporary problems centering around the question: What solution can the recent controversies in the science provide as the adequate approach to organismic behavior? The present edition is essentially a translation of the German original, and constitutes a part of the American Psychology Series under the general editorship of Henry E. Garrett.

**THE ART OF ANAESTHESIA.** By Paluel J. Flagg, M.D. Sixth Edition. Philadelphia, 1939. J. B. Lippincott Company.

Paluel Flagg is nationally known for his work on the problem of asphyxia, especially as related to anesthesia. He also has evolved direct methods of artificial respiration—now known as the Meltzer-Flagg technique. Because of his efforts a Committee on Asphyxia was organized by the American Medical Association. He has contributed important articles on this subject in *The American Journal of Surgery*. This year he established a Department of Pneumatology in connection with the medical department of the World's Fair in New York. We recite these facts that the reader

will get a slight idea of the author's background and work. This work is now a standard; this, the sixth edition, has been rewritten in parts and many new subjects and features added, bringing it up to date. To physicians who have anything to do with anesthesia and to nurse-anesthetists, Dr. Flagg's book is a necessity.

**CANCER HANDBOOK OF THE TUMOR CLINIC OF STANFORD UNIVERSITY SCHOOL OF MEDICINE.** Edited by Eric Liljencrantz, M.D. San Francisco, 1939. Stanford University Press. Price \$3.00.

The methods of cancer diagnosis and treatment outlined in this handbook are founded on present practices at the Stanford University Tumor Clinic and represent the integrated experience of all its active members. It is in miniature a graduate course, elementary enough for any medical practitioner, yet complete enough to prepare and enlighten him for the proper handling of his cancer patients.

The book is limited to 114 pages, has fifty figures, an extensive bibliography and an index. Radiation therapy, the treatment of cancer in various organs, nervous system tumors, the leucemias and other subjects more or less allied, are discussed.

**OTOLARYNGOLOGY IN GENERAL PRACTICE.** By Lyman G. Richards, M.D. New York, 1939. Macmillan. Price \$6.00.

The usual manual of ear, nose and throat diseases is designed for the specialist in that field. Dr. Richards, on the other hand, has planned his otolaryngology for the general practitioner. In view of the fact that about 20 per cent of a general practice consists of work in this branch of medicine, such a manual fills a long-felt want.

In line with his purpose, details of surgical procedures have been omitted, since these would normally fall within the province of a consulted specialist. Chief emphasis has been placed on the ordinary procedures of examination and diagnosis, with treatment of the conditions commonly seen. The significance and therapy of pain or discharge in the ear, deafness, sore throat, epistaxis, hoarseness, cough, dysphagia and headache are discussed. The technique of tonsillectomy, adenoidectomy, intubation and tracheotomy is given since these are procedures which any practitioner will need to have at his command.

The illustrations are planned from the same point of view—they are simple and diagrammatic, showing procedures to be accomplished and the manner in which they are carried out.

Though the specialist will find little grist here for his mill, the general practitioner will find the book a valuable aid.

**TREATMENT BY MANIPULATION.** By A. G. Timbrell Fisher, F.R.C.S. Third Edition of "Manipulative Surgery." New York, 1939. Hoeber. Price \$3.75.

This book, now offered in a third edition, was written with the object of drawing the attention of the medical profession to the importance and value of manipulative treatment in certain selected cases, particularly in the sequelae of injuries and diseases affecting the joints, muscles, tendons, and fasciae. This edition has new chapters on the cult of osteopathy and the prevention of adhesions, and a number of new illustrations. It is a sanely written monograph of 255 pages, which will be of value to those who have employed this form of treatment and to those who may find uses for it now that it is brought to their attention.

**MATERNAL CARE AND SOME COMPLICATIONS.** Edited by F. L. Adair, M.D. Chicago, 1939. University of Chicago Press. Price \$1.50.

This small book of 194 pages could well be assigned as compulsory reading for every general practitioner who "does obstetrics." Marked improvement in the handling of the pregnant woman would be bound to result.

Section I of the little text deals with maternal care, section II with complications such as emesis and toxemia, hemorrhage and puerperal infection.

The style is delightful, the subject matter well handled and the whole book well worth the time spent in its preparation.

**GYNECOLOGIC OPERATIONS AND THEIR TOPOGRAPHIC ANATOMIC FUNDAMENTALS.** By Heinrich Martius, M.D. Translated under the editorial supervision of W. A. Newman Dorland, M.D. Chicago, 1939. S. B. Debaur. Price \$10.00.

The other evening the reviewer entertained his staff of residents, interns and younger assistants. They chanced upon this book in a stack awaiting review, and their enthusiasm was instantly aroused.

One does not learn to operate from a book—that goes without saying—but a book which depicts clearly the steps of the various gynecologic procedures is a definite help. The text here is concise and clear since the translators have done a creditable job. The illustrations, most of them in color, could hardly be finer. They are done so well that the point gets across immediately to the reader. To the young man interested in operative gynecology, this is a good purchase to recommend.

**THE MECHANISM OF THOUGHT, IMAGERY AND HALLUCINATION.** By Joshua Rosett, M.D. New York, 1939. Columbia University Press. Price \$3.00.

This short book reveals for the first time the foundations of the three primary mental functions. It covers the evolution and dissolution of the nervous system, the emotional state, the relation of the emotions to the conscious, sensory or informative state, the expression of subjective experience of emotion, will, nerve signalling and the representation of symbols. A second section deals with the mechanism of thought, imagery and hallucination, with injuries and diseases of the nervous system and with the phenomena of attention and sleep. Each chapter is concluded with a summary and a list of references, and the book as a whole is indexed.



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